Deserts: Driest Places on Earth

Deserts constitute the second most extensive environment system of the Earth. They are an important sub-component of the global climate system. The book briefly describes how deserts are formed, some great deserts of the world, and desertification, desert landforms, mineral resources in deserts, water in deserts, desert plants, desert animals, and people living in deserts. The book provides a bird's eye view of the factors accelerating process of desertification and how it will have devastating consequences for both humans and the environment and its possible impact on the climate of even those regions that are quite remote from the actual desert areas and how to stop it.

About the author

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planet earth

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doing for centuries. Today there is consensus that human activities like burning of fossil fuels and consequent pumping of gases like carbon dioxide into atmosphere have been responsible for the earth getting hotter and hotter. Today, there are threats to our planet arising from climate change, degrading environment, the growing rate of extinction of species, declining availability of fresh water, rivers running dry before they can reach sea, loss of fertile land due to degradation, depleting energy sources, incidence of diseases, challenge of feeding an exponentially growing population, and so on. The human population is now so large that the amount of resources needed to sustain it exceeds what is available. Humanity's environmental demand is much more that the earth's biological capacity. This implies that we are living way beyond our means, consuming much more than what the earth can sustain.

To draw the attention of the world to these aspects and in an attempt to establish that environment is where we live; and development is what we all do in attempting to improve our lot, within that abode, the United Nations has declared the year 2008 as "The Year of the Planet Earth". It is hoped that with the cooperation of all we shall be able to save the biodiversity and the life on this planet. A host of activities and programmes are being organized all over the world for this purpose. One of the important aspects is to make people aware about the challenges we face and the possible solutions to save this planet from heading towards catastrophe. It is with such thoughts that Vigyan Prasar has initiated programmes with activities built around the theme "The Planet Earth". The activities comprise of development and production of a series of informative booklets, radio and television programmes, and CD-ROMs; and training of resource persons in the country in collaboration with other agencies and organizations.

It is expected that the present series of publications on the theme "The Planet Earth" would be welcomed by science communicators, science clubs, resource persons, and individuals; and inspire them initiate actions to save this fragile abode of ours.

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Preface

The English word desert comes from the Latin term *desertum*, meaning "an unpopulated place", and correctly reflects the harshness of the environment where few, if any live. The common perception about deserts is that these are hot, dry areas where it almost never rains and the dead and dreary sands stretch away as far as the eyes can see. While there may be an element of truth in this commonly held idea, there are many fascinating facets that come to life when desert regions are given a closer look. It is correct that deserts are generally dry places on Earth. If a region receives an average of less than 25 centimetres of rain each year, scientists classify it as a desert. But in addition to the hot, dry deserts there are also the so-called Cold deserts. When cold and unmelting snow create environments where lifeforms face formidable challenges for survival, the area is called a cold desert.

Deserts constitute the second most extensive environment system of the Earth. They are an important sub-component of the global climate system. But the threat is that thousands and thousands of hectares of productive land are becoming desert-like and thus, unproductive. This process is termed as desertification. There is enough evidence

The theme of the book is very relevant to India and its people. India's arid zone covers about 39 million hectare (Mha). This is about 12 per cent of the total area of the country. Kofi Annan pointed out in 2003 that every year in India, dry spells and deforestation turn 2.5 million hectares into wasteland, while elsewhere in Asia, sandstorms are becoming a growing threat to the economy and the environment.

A large number of Indians live in deserts. The Thar Desert in Rajasthan is the most highly populated hot desert in the world.

We must act now otherwise it would be too late to tackle the situation. It would require collective action. The first step is to create awareness among the people and this book may be perceived as a small effort towards the goal.

Sobodh Mahanti

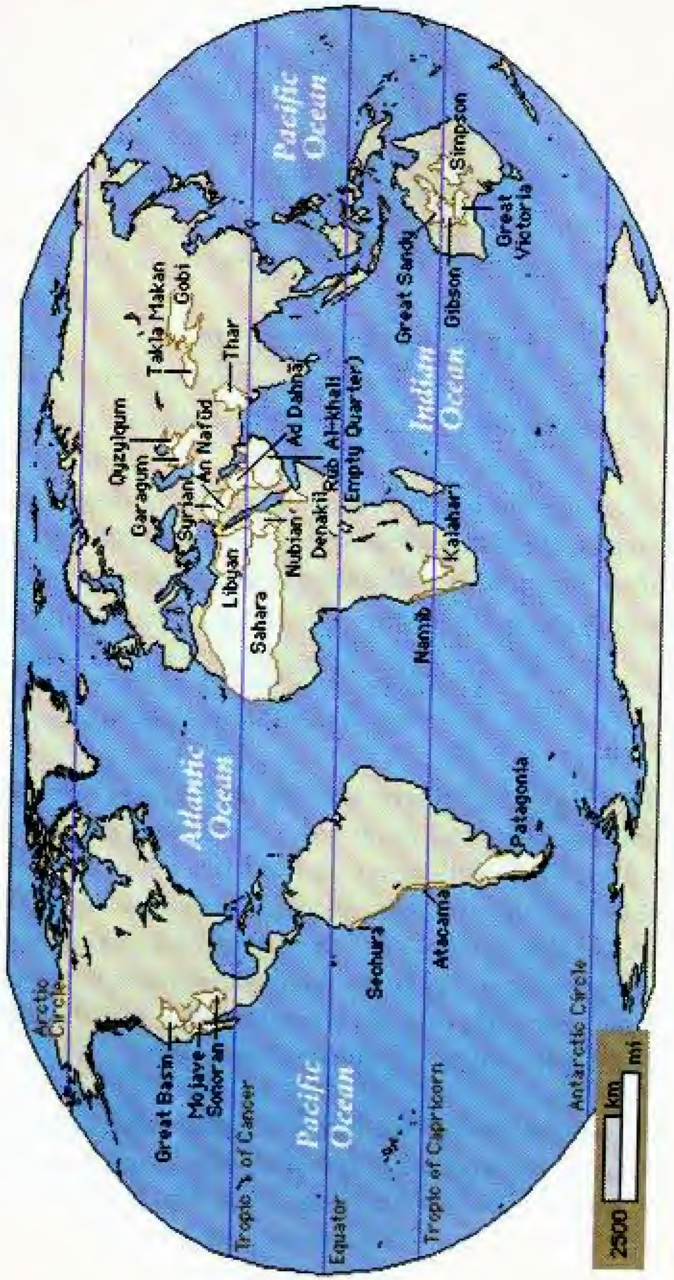
Introduction

"I've crossed these sands many times. But the desert is so huge, and the horizons so distant, that they make a person feel small, and as if he should remain silent."

— *A camel driver on the Sahara Desert in The Alchemist by Paulo Cohello*

After the oceans, deserts are one of the most extensive environment systems and cover vast areas of the Earth. When we talk about the well-being of the Planet Earth or of a sustainable Earth system, we cannot ignore deserts. According to Tony Allan and Andrew Warren deserts (both hot and cold) comprise up to 40 per cent of the terrestrial surface. While this may not be a consensus figure, it can be safely said that one-third of the Earth's surface is covered by deserts.

Most deserts lie near the Tropic of Cancer and the Tropic of Capricorn—the two lines of latitude lying about 30 degrees from the equator. The area between these two lines is called the Torrid Zone. Almost all continents have deserts. A very high proportion of the continents of Africa and Australia are



Desert areas of the World

deserts. Most parts of southwest Asia and Central Asia and all the south-western states of the United States and much of northern Mexico are deserts. Small parts of South America are deserts.

When people think of deserts, the following images come to their minds: hot and arid land, no rain, vast expanses of sand, reddish brown soil, a brilliant blue sky, no vegetation or very few plants—mostly thorn. The camel is the only animal to be truly at home in the deserts. But the truth is far removed from this. It is not very common to find sand in a desert. Small rocks, pebbles and loose gravel are to be found on the surface of the most of the deserts. Only about 15-20 % of the world's desert is covered by pure sand. The desert landscapes are the result of the action of wind and water over millions of years. And some areas are of spectacular natural beauty.

Contrary to what most people believe, all deserts are not hot. Some deserts near the North and South Poles are so cold that all moisture is frozen solid. But, all deserts have two things in common: they are dry, and they support little plant and animal life.

There is a wide temperature variation between day and night in the deserts. Temperatures rise during the day but as the Sun sets, deserts become cooler. Thus deserts alternately warm and cool. This cycle of alternate heating and cooling causes the rocks to cyclically expand and contract. The continuous cycles of expansion and contraction breaks the rocks into smaller fragments. The fragments thus produced are blown away by the desert wind and grind down other rocks. This leads to gradual wearing away of the rocks. As the process continues the fragments eventually form the grain-like sand that we see on desert surfaces.

Desert sand is not the same sand that we find on beaches. Desert sand is larger and rounder. The colour of the sands also varies from desert to desert. Most of the sand in deserts is in the form of sand sheets and sand seas—vast regions of undulating dunes resembling ocean waves "frozen" in an instant of time. Sometimes the winds blow away almost all the sand, exposing bare rocks or stony ground.

Deserts are not of recent origin. These have existed throughout the Earth's history and have persisted for millions of years. Deserts are believed to have been present even when glaciers covered large portions of the Earth during the great Ice Ages. Scientists agree that some deserts, though perhaps smaller than the present ones, have always been present on Earth. A particular desert may disappear because of changes in climate. Similarly a non-desert region may become a desert. But this kind of transformation does not take place suddenly. It takes a very long time to come to pass. Deserts are not static. They expand and contract within well-defined zones.

Rainfall varies from desert to desert and from year to year. The driest deserts may receive no rainfall for several years. The Atacama Desert has faced the world's longest drought. In some part of the desert no rain fell here for 400 years (from 1571 until 1971). On the other hand, a desert may receive as much as 430 millimetres of rain in a single year. Rainfall may be spread out over many months or fall within a few hours. For example, in the Atacama Desert again, more than 12.5 millimetres of rain fell in one shower after four years of drought. The point to note here is that the Atacama Desert is considered the world's driest desert. Such conditions often cause flash floods, which sweep vast quantities of mud, sand, and boulders through gullies and dry river beds (sometimes called wadis or arroyos). The water, however, soon evaporates or disappears into the ground.

Atacama, the world's driest desert

Deserts may be extremely hot or extremely cold. The daytime air temperature reaches 58 degrees Celsius in the Sahara and soil temperature may reach 80 degrees Celsius. For half the year, the average temperature of the Mongolian desert is below the freezing point. In Antarctica, the winter mean temperature is –30 degrees Celsius. Even within a particular desert there is an extreme temperature range between day and night. Most deserts have a low temperature at night. This is because air in the desert contains very little moisture and it holds little heat. So soon after the Sun sets in, the desert cools quickly.

It is generally believed that deserts support very little life. While compared to wetter regions, deserts do support very little life but certainly they are not devoid of life. In fact in spite of existing extreme conditions deserts support an extraordinary web of life, both plants and animals. The diversity in life found in deserts is truly amazing.

Deserts are natural laboratories in which we can study the interactions of wind and sometimes water on the arid surfaces of

planets. They contain valuable mineral deposits that were formed in the arid environment or those that were exposed by erosion. Deserts are places where human artefacts and fossils have been naturally conserved. The misuse of these lands is a serious and growing problem in many parts of our world.

Desertification of dry land has emerged as one the major problems for human beings. More and more of the world's land surfaces are being turned into deserts or desert-like condition. Desertification leads to other environmental crises like depletion of biodiversity and global warming. Estimates suggest that dry lands cover about one-third of the Earth's total land surface. Seventy-five percent of the world's drier lands are affected by desertification, and every year thousands and thousands of hectares of agricultural land become virtual deserts.

The Sahara is thought to be advancing southwards by about 5-10 kilometres per year, which is a very considerable distance, when one remembers that the Sahara is 5,150 kilometres across at its widest point. More than 250 million people are directly affected by desertification and about 1 billion people are potentially at risk. The new deserts, which are being created, are not necessarily hot, dry and sandy places. These newly created deserts are areas where the soil has been so mistreated by humans that it is now useless for growing crops.

Human activities such as overcultivation, overgrazing, deforestation and poor irrigation practices, along with climate change, are turning once fertile soils into unproductive and barren patches of land. Arable land per person is shrinking throughout the world, threatening food security, particularly in poor rural areas, and triggering humanitarian and economic crises. In areas where seasonal rainfall is unreliable soils are

easily ruined. According to the United Nations Environmental Programme (UNEP), (see www.un.org/ecosocdev/geninfo/sustev/desert.htm) most of the endangered dry land regions lie near the world's five main desert areas:

- The Sonoran Desert of northwest Mexico and its continuation into southwest United States.
- The Atacama Desert, a thin coastal strip in South America between the Andes and the Pacific Ocean.
- A large desert area running eastward from the Atlantic Ocean to China, including the Sahara desert, the deserts of Iran and the former Soviet Union, the Great Indian Desert (Thar) in Rajasthan, and the Takla-Makan and Gobi Deserts in China and Mongolia.
- The Kalahari Desert in southern Africa.
- Most of Australia.

We need to aggressively contain the process of desertification. Otherwise the very existence of human beings on Earth will be threatened.

What are Deserts?

"The term desert conjures up vistas of rolling, featureless sand and intense, dry heat. While these conditions are certainly found in many places, the world's deserts are far more varied in character with some having rocky landscapes, occupying high plateaus, and others dominated by open salty lake beds."

—*Earth, James F. Luhr, Dorling Kindersley Ltd. (2003)*

The term desert is familiar to us, but to define it scientifically, is not an easy task. This is because the scientists themselves have put forward more than one definition for deserts. This is because the term "desert" covers a great diversity of landscapes. In deserts we see a range of environmental conditions.

In geography, a desert is defined as a landscape form or region that receives little precipitation (a depositing of rain, snow, sleet etc.,), say about 250 mm per year. In general terms, a desert can be described as a virtually barren and arid region where there is only sparse vegetation cover. Only those plants

can survive on deserts, which have specialized skills in storing water or drawing it from far below the ground level. The thin soils, being continually attacked by wind, lack humus and so are generally infertile. The moisture lost through evaporation is greater than that gained in rainfall. The rainfall is minimal and sporadic. The drought period is usually longer than one year except for the Antarctica. The extremely dry and hot conditions make crop growth quite impossible.

Hot Deserts and Cold Deserts

There are as many classification systems of deserts as there are types of deserts in the world. There are cold deserts and hot deserts. Deserts with average temperature above 30 degrees

Cold desert of the Great Basin near Lunar Crater, Nevada

Celsius are called hot deserts. The deserts in non-polar regions are hot places. Non-polar deserts are hot because there is hardly any water. While arid and extremely arid lands are actual deserts, semi-arid grasslands generally are referred to as steppes.

Cold deserts are those which have average winter temperatures below 0 degree Celsius. Cold deserts situated in the polar region remain covered in snow throughout the year. The regions called cold deserts receive very little precipitation and what little they do, remains frozen as snow pack. Where the freezing temperatures are experienced for a short season, the cold deserts are referred to as tundra. When the temperature remains below freezing point throughout the year, the cold deserts are nothing but barren ice caps.

Desert Precipitation

Most classifications are based on combinations of the number of days of rainfall, the total amount of annual rainfall, temperature, humidity, or other factors. Peveril Meigs classified deserts (for UNESCO) in 1953. He divided the world's desert regions into the following three categories based on the amount of precipitation received:

1. Extremely (or hyper) arid lands. These face at least 12 consecutive months without rainfall. Average annual rainfall is less than 25 millimetres.
2. Arid lands. These receive less than 250 millimetres of annual rainfall.
3. Semi-arid lands. These get a mean annual precipitation of between 250 and 500 millimetres.

However, it has been found that lack of rainfall alone cannot be taken as the only factor for defining a desert. For example, Phoenix, Arizona, USA, receives less than 250 millimetres, of precipitation annually, and this region is recognized as a desert. But this not true for the North Slope of Alaska's Brooks Range. This region also receives less than 250 millimetres of precipitation per year, but is not generally recognized as a desert region.

Koppen Climate Classification System and Deserts

The Koppen Climate Classification System defines the general climatic conditions of the world. It was developed by German climatologist Wladimir Koppen (1846-1940) and introduced in 1928 as a wall map co-authored with his student Rudolph Geiger. The Koppen system of climate classification relates the definition of a desert to plant and animals by characterising a desert as a place where more water is lost through evaporation than is gained from precipitation.

Deserts are also classified by taking temperature as a parameter. There are hot deserts (with average summer temperatures above 30^0 C) and cold deserts (with average winter temperatures below 0^0 C). According to some estimates 43 percent of the total desert regions are hot deserts and 24 percent, cold deserts.

Geographical Distribution and Weather Patterns of Deserts

Deserts are also classified by their geographical location and dominant weather pattern as indicated below:

1. Trade wind deserts
2. Mid-latitude deserts.
3. Rain shadow deserts
4. Coastal deserts
5. Monsoon deserts
6. Polar deserts.

Dominant Landforms and Deserts

Deserts can also be classified based on the dominant land form in a particular desert area. According to this classification there are six forms of deserts:

1. Mountain and basin deserts;
2. Hammada deserts, which comprise of plateau-like landforms;
3. Regs, which consist of rock pavements;
4. Ergs, which are formed by sand seas;
5. Intermontane Basins; and
6. Badlands.

Mountain and basin deserts

Mountain deserts are arid places with a very high altitude. The most prominent example is found north of the Himalayas, in parts of the Kunlun Mountains (mountain systems in Western China, between Tibet and Xinjiang province) and the Tibetan Plateau. Many locations within this category have elevations exceeding 3,000 metres (9,843 feet). These places owe their profound aridity (the average annual precipitation is often less than 40 mm) to being very far from the nearest available sources of moisture.

Hammada deserts

The word Hammada means 'stony desert'. A hammada desert is a desert plateau of hard, wind-swept bed-rock covered with

Hammada desert

a thin layer of sand, pebbles, etc. The largest hammada is Hammada du Draa in north west Sahara desert

Regs

Deserts where the dominant landforms are desert pavements are called regs. Regs are formed when bedrock matrices are progressively eroded by wind till there are only pebbles of more resistant rocks such as chert and flint left behind. These pebbles form a pavement by becoming very closely packed. The formation of the desert pavement prevents further degradation of the desert surface lying beneath the pavement.

Ergs

An erg is a large, relatively flat area of desert covered with wind-swept sand with little to no vegetation cover. The term takes its name from the Arabic word erg, meaning "dune field". The largest ergs are in northern and southern Africa, central and western Asia, and Central Australia.

Intermontane Basins

Deserts lying between mountain ranges are called intermontane basins.

Badlands

Badlands are arid terrain with extensively eroded clay-rich soil. Canyons, ravines, gullies, and other such geological forms are common in badlands. Badlands are literally Bad-lands. They contain steep slopes, loose dry soil, slick clay, and deep sand, all of which impede travel and make the surroundings unfit for other uses. Badlands form in arid regions with infrequent but intense rain-showers, sparse vegetation, and soft sediments—perfect for massive erosion. Badlands are common in the United States of America and Canada.

Other Types of Deserts

There are a few other types of deserts as well. It has been found that large, sandy areas remained inactive because they were stabilized by vegetation. Such inactive and stabilized sandy areas are called paleodeserts. Such paleodeserts are found to

The desert stabilised by vegetation

extend well beyond the present margins of core deserts, such as the Sahara. Today's Sahara desert has been changing between desert and fertile savanna.

Deserts that exist on other planets are called extraterrestrial deserts.

3

How are Deserts Formed?

"The record of rocks shows that there have been deserts on Earth for hundreds of millions of years. Throughout this time they have been constantly on the move in response to changing climates and drifting continents."

— Martin W. Holdgate in
Deserts: The Encroaching Wilderness

Most desert regions are the result of large-scale climatic patterns. The great deserts of the world were formed by various natural processes interacting over long periods of time. Deserts are not static. Under normal conditions, they grew and shrunk independent of human activities.

Desertification does not proceed in a linear fashion and there is no easy pattern for mapping the process of desertification. The process by which a productive land is degraded is not a one-step process. Rather, it is a complex process. There is no single cause for land degradation. The rates

at which lands are degraded are not same at every place. The rates vary under different climatic conditions. Desertification may intensify a general climatic trend toward greater aridity, or it may initiate a change in local climate.

The advancement of deserts is an erratic process. There is no direct relationship between desertification and the presence of a nearby desert. Poor land management can rapidly convert areas situated far from natural deserts into barren soil, rock, or sand. The onset of desertification is also not immediately recognized. We recognise it only when the process is well underway. So, often, there is no way of knowing what the state of the ecosystem was, or even the rate of degradation, before the land was desertified. There is no consensus whether desertification, as a process of global change, is permanent or how and when and if it can be halted or reversed.

In general, deserts are created by the presence of dry air. The average humidity (moisture in the air) is between 10 and 20 percent. The main causes for desert formation are:

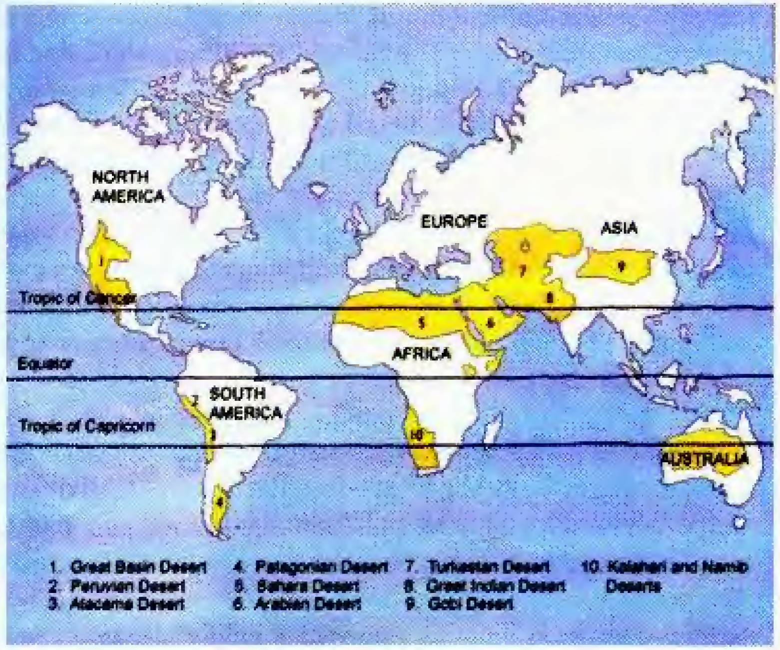
- High-pressure zones;
- Cold ocean currents;
- Continentality; and
- Rain shadows.

However, usually just one contributory cause is not responsible for creating a desert.

High Pressure Zones

The air in the Earth's atmosphere is in constant motion. The movement of the air takes place in response to the heating of the Sun. The worldwide movement of the air forms the general circulation of the atmosphere and by which, warmer air is carried from equatorial areas to high altitudes and cooler air

returns to the tropics. Most of the non-polar deserts occur in two broad trade wind belts, at 20-30 degree north and south of the Equator, along the Tropics of Cancer and Capricorn. Desert areas develop under the influence of the permanent high-pressure areas.



Deserts develop under the influence of the permanent high-pressure areas

As the Earth turns on its axis, large air swirls are produced. The Earth rotates around its axis at about 1676 km per hour at the equator but at nearly zero speed at the poles. Hot air at the Equator rises and spreads north and south before cooling. Once the air cools, it condenses and releases its moisture over the tropical zones. An equatorial zone of low atmospheric pressure is created. The two tropical zones are at high pressure. Nearer to the poles are two cold low-pressure belts. The polar region has descending air of high pressure. As

the denser air sinks towards the ground to the two subtropical high-pressure belts, wind is created (easterly trades). This wind is hot and it completely lacks moisture. The dry wind picks up moisture, drying out the land. The belt in the northern hemisphere is along the Tropic of Cancer and includes the Gobi Desert in China, the Sahara Desert in North Africa, the deserts of south-western North America, and the Arabian and Iranian deserts in the Middle East. The belt in the southern hemisphere is along the Tropic of Capricorn and includes the Patagonia Desert in Argentina, the Kalahari Desert of southern Africa, and the Great Victoria and Great Sandy Deserts of Australia.

Many deserts are located, around 30 degrees north and 30 degrees south latitudes in the high-pressure zones. These zones are created by Hadley Cells, a convection pattern resulting from solar energy. The process can be understood better by describing it stepwise:

1. Air is heated in greater amounts at the equator because the angle of sunlight hitting the Earth is close to perpendicular. This means that less amount of surface area is exposed to higher amounts of radiation, which results in increased warming.
2. This warm air expands and rises at the Equator, creating low-pressure zones.
3. These low-pressure zones suck in moisture-bearing air masses, or rain-clouds, while the equatorial air masses travel towards the poles. Also, as the air masses rise they become cooler and so cannot retain much moisture. This is the reason why there is high rainfall at the Equator and consequently, green equatorial rainforests.
4. As these equatorial air masses travel away from the Equator, they cool and descend closer to the surface of the globe.
5. High air pressure and increased dryness result as the air masses near the surface.

6. Moisture is sucked from the surface at 30 degrees north and 30 degrees south. Because of the increase in temperature the air masses are able to hold more water.

Cold Ocean Currents

Sea temperatures influence the water extraction rate and global pattern of water currents. Far from the desert belts, established in the polar region, cold currents move to the Equator and may come up against the edges of the continents. Up-welling from the very cold depths adds masses of cold water to them. Cold-water ocean currents can cause moist air to drop its moisture over the ocean. The resulting dry air quickly dries up ground moisture along the coastal regions as it moves inland. The deserts formed by cold ocean currents are called coastal deserts.

Coastal deserts are generally found on the western edges of continents near the Tropic of Cancer and Tropic of Capricorn. This is because they are formed by the action of cold ocean currents that parallel the coast. These deserts are less stable than other deserts. Winter fogs, produced by up-welling cold currents, frequently blanket coastal deserts and block solar radiation. Coastal deserts are relatively complex because they are at the juncture of terrestrial, oceanic, and atmospheric systems. The Atacama Desert, the Earth's driest desert, is a coastal desert.

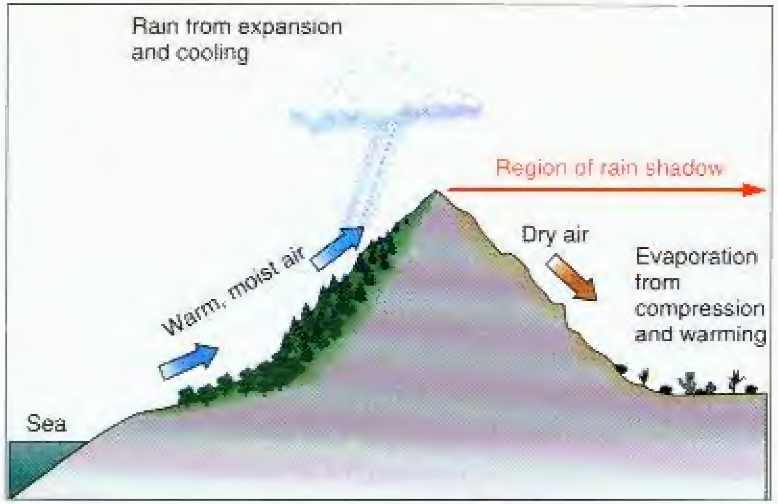
Continentality

Less water from the ocean, via winds, tends to reach the areas located more toward the interior of a continent. Remoteness from the sea means that there is less chance of precipitation. This phenomenon is known as continentality. Continentality causes greater extremes in both temperature and precipitation the farther inland an area is. A characteristic of regions that

lack the temperature moderating effects of the sea is that they exhibit a greater range of minimum and maximum temperature, both daily and annually. The deserts of Central Asia are best examples of deserts, in the formation of which continentality plays a major role.

Rain Shadow Deserts

Tall mountain ranges prevent moisture-rich clouds from reaching areas on the leeward or protected side, of the range.



Region of the rain shadow

As air rises over the mountain, water is precipitated and the air loses its moisture content. Dry air descending over the leeward slopes picks up moisture from the soil, drying it out. A desert is formed in the lee-side "shadow" of the range. Rain shadows have been one of the main factors in the formation of deserts in North America, especially the Rocky Mountains in the Western United States.

Polar Deserts

Polar deserts are areas with annual precipitation less than 250 millimetres and a mean temperature during the warmest month of less than 10° C. Polar deserts cover nearly 5 million square kilometres and are mostly bedrock or gravel plains. Sand dunes are not prominent features in these deserts, but snow dunes occur commonly in areas where precipitation is locally more

Sand dunes are not prominent features in polar desert

abundant. Temperature changes in polar deserts frequently cross the freezing point of water. This "freeze-thaw" alternation forms patterned textures on the ground, as much as 5 metres in diameter.

Great Deserts of the World

"Deserts may occur in areas of high atmospheric pressure, such as the Sahara, or near the west coast of continents cooled by ocean currents (e.g., the Atacama and Kalahari Deserts). They are also found in continental interiors where mountain barriers restrict precipitation, such as the Gobi Desert".

— *The Macmillan Encyclopedia, 1981*

Two desert belts encircle the world on either side of the Equator. There are extensive deserts on the continents of Africa and Australia. The largest desert of the world is located in northern Africa. Deserts cover almost all of southwest Asia and Central Asia. Considerable parts of the south western states of the USA (California, Arizona, Nevada, and New Mexico) are deserts. Much of northern Mexico is also desert. Deserts in South America occupy only narrow coastal belt in Chile and Peru. There are no deserts in Europe.

Major Deserts of the World

The major deserts (name, type, location, approximate size) are listed below along with brief descriptions.

1. **Arabian Desert:** Hot; arid and extremely arid. Arabian Peninsula; 2,330,000 square kilometres.
2. **Atacama Desert:** Hot; extremely arid and arid; Chile; 140,000 square kilometres.
3. **Australian Desert:** Hot; arid and semiarid; Australia; 1,500,000 square kilometres.
4. **Chihuahua Desert:** Hot; arid; Mexico and USA; 518,000 square kilometres.
5. **Death Valley Desert:** Hot; arid; California, United States; 13,812 square kilometres.
6. **Gobi Desert:** Cold; arid and semiarid; China and Mongolia; 1,300,000 square kilometres.
7. **Great Basin Desert**: Cold; arid; USA; 409,000 square kilometres
8. **Kalahari Desert**: Hot; arid Southern Africa 500,000 square kilometres.
9. **Kara Kum Desert**: Hot; arid; Turkmenistan; 297900 square kilometres.
10. **Mojave Desert:** Hot; arid California and Nevada, United States 65,000 square kilometres.
11. **Namib Desert:** Hot; arid Botswana, eastern Namibia, and northern South Africa 135,000 square kilometres.
12. **Negev Desert**: Hot; arid; Israel; 12,170 square kilometres.
13. **Patagonian Desert**: Cold; arid Argentina 673,000 square kilometres.
14. **Sahara Desert:** Hot; extremely arid and arid; North Africa 8,600,000 square kilometres.
15. **Sonoran Desert:** Hot; arid; Arizona, USA; 275,000 square kilometres.
16. **Takla Makan Desert**: Cold; arid; Xinjiang Province, China; 327, 000 square kilometres.

17. **Thar Desert**: Hot; extremely arid; India and Pakistan (200,000 square kilometres)

The areas given against the deserts are approximate estimates that may vary in different accounts. This is because the geographical area of a desert is not very often distinctly defined.

A picture of Sahara desert

The Arabian Peninsula Desert

The Arabian Peninsula Desert stretches from Syria in the north to Yemen and Oman in the south. It covers an area of about 230,00,00 square kilometres. In many ways the Arabian Peninsula Desert is similar to the great Sahara Desert. The Arabian Peninsula Desert may be viewed as an extension of the Sahara Desert. The only barrier between the two is the Red Sea. Like the Sahara, the Arabian Peninsula Desert has vast seas of sands.

The Arabian Peninsula Desert is very arid. The average annual rainfall for most of the years is less than 100 mm. It is a very hot place. The maximum temperature in the central part of the desert can reach 49^0 C. The temperatures come down a little in winter and occasionally touch the freezing point at night in winter months.

The Peninsula contains two-thirds of the world's petroleum resources. The southeastern part of the peninsula is the most arid region of the desert. It is in this part that the famous Ar Rub'al Khali or Empty Quarters is located. This region is uninhabited as its name indicates.

The Atacama Desert

The Atacama is a coastal desert. It is a narrow coastal strip in northern Chile having an average width of about less than 160

Atacama desert

km. In length it extends about 960 km. The desert is a virtually rainless plateau made up of salt basins, sand, and lava flows This is the driest place on the Earth. Average annual rainfall in Atacama Desert is less than 15 mm. In some parts there is no record of rainfall in living memory. A place called Calama in the Atacama Desert did not receive any rain for 400 years (1570 to 1971). However, there is sufficient rainfall in some parts of Atacama to create obvious signs of erosion by surface water.

There are human settlements in the Atacama. These settlements have grown around four groups of oases—Arica near the Peruvian border, the eastern edge of the Pampa del Tamarugal and the basins of the Loa and Copiapo rivers. The main crops grown in these areas are corn and alfalfa. The chief minerals found in Atacama are nitrates, copper and silver. The world's largest copper mine is located in Chuquicamata in the Atacama Desert.

The Australian Desert

Deserts cover a large part of Australia. The Great Sandy Desert, the Gibson Desert and the Great Victoria Desert combine to fill more than half of Western Australia. To the east lies the Tanami Desert, the Simpson Desert, and Sturt's Stony Desert.

The Australian deserts of today were once covered by sheets of polar ice. Before that, these regions were covered by great areas of shallow seas. Australia started drying up about a few million years ago. Parts of Australia became arid less than one million years ago, which on the geological time scale is not a very long period. Since Australia is inching northwards, its desert regions will, one day, reach the Equator and once again become tropical regions.

The Australian Desert can be broadly divided into three broad categories:

- Clay plain deserts,
- Sandy deserts, and
- Stony deserts.

The Great Sandy Desert: It is the largest among the Australian deserts. Its size is about 340,000 square kilometres. It is a flat area between the rocky ranges of the Pilbara and the Kimberley. No other Australian desert extends to the coast. Average rainfall here ranges between 250 to 300mm. However, intense heat evaporates much of the rain before plants and animals can utilise it. Daytime temperature ranges between 38 to 42 degrees Celsius.

The Tanami Desert: It covers an area of 37,500 square kilometres. It lies east of the Great Sandy Desert. The Tanami Desert is one of the most isolated and arid places on Earth. The vegetation mainly constitutes of tough spinifex grasses, small shrubs and spiny acacias. It has the largest population of the endangered Rufous hare wallaby.

The Simpson Desert: The Simpson Desert is located in the centre of Australia and covers approximately 170,000 square kilometres. It is an erg and contains the world's longest parallel sand dunes held in position by vegetation. Big Red (Nappanerica), the most famous dune is 40 metres in height.

Compared to other Australian deserts the rainfall in the Simpson Desert is low and irregular. Interestingly, beneath the Simpson Desert lies the Great Artesian Basin. Waters from this rise to the surface at several natural springs and artificial bores. Unfortunately over-exploitation has reduced the output in

recent years and there are fears that the springs may dry up. The chief vegetation in this desert is spinifex grasses and shrubs.

The Great Victoria Desert: It covers an area of 338,500 square kilometres. It has extensive dune fields. Besides the familiar types of dunes, it has a special type of dunes called lunctte dunes that are found only in Australian deserts. These dunes are crescentic and made of mostly of clay. It also has gibber plains, the soil surface of which is covered by closely packed pebbles that are often glazed by iron oxides. It has a good vegetation cover. The Great Victoria Desert is well-known for its reptilian fauna including the bizarre Thorny Devil.

The Gibson Desert: The central section of the vast desert region of Western Australia is covered by the Gibson Desert. It covers an area of 156,000 square kilometres. It lies between the Great Sandy and the Great Victoria Deserts. The desert was named after the Australian explorer Alfred Gibson who unsuccessfully attempted to cross it in 1874. Among the animals, Red kangaroos are most commonly found.

Sturt's Stony Desert: The desert is characterised by immense gibber plains, red soil, and sand dunes. The desert derives its name from Charles Sturt who in 1844 named it thus. Apparently he was trying to reach the exact centre of Australia and the stony ground here caused his horses to limp and wore down the hooves of his cattle and sheep. The area is poorly studied. It was first explored in the 19th century by Strezleki, Sturt and Eyre. The flora and fauna in the desert is sparse and typical of the region. Sparse saltbush scrubs dot the landscape. These scrubs thrive in dry, salty environments and they act as fodder for sheep.

Among the minerals found in the Australian Deserts, opal is the most important. Other minerals found include gold, lead, zinc and iron.

The Chihuahua Desert

The Chihuahua Desert is the largest desert in North America. The desert is named after the Mexican province located at its centre. It covers an area of 518,000 square kilometres. It lies sandwiched between Sierra Madre ranges of Mexico and extending north into New Mexico, Texas and Arizona. It is very hot in summer but in winter frosts occur at night. Temperatures range from –30 to 40 degrees Celsius. Rain falls mostly in summer. The average annual rainfall at Chihuahua Desert is about 250 mm. The Chihuahua is a high altitude desert and most parts of this desert lie at 1000-1500 metres. The Chihuahua Desert supports a wide range of plant and animal life. At lower altitude, the vegetation of the desert is dominated by Creosote bush and Tarbush. Plants belonging to the Yucca family are found at relatively higher altitudes. The Western Diamond-back Rattlesnake, a highly venomous viper is found here.

The Death Valley

The Death Valley in California, USA is one of the hottest places on Earth. Temperatures here can touch 54 degrees Celsius on a summer day. And it can fall to below freezing on winter nights. The place gets heated because of the mountains that encircle the valley. The Death Valley receives very little rainfall. Because of the inability of the soil to absorb bulk of the water, the Valley is prone to flooding during heavy rains. So there are, at times, dangerous flash floods. In prehistoric time, the Valley was inundated by the Lake Manly and today, the Amargosa River and Furnace Creek flow through the desert for a while before they disappear into the sands. The Death Valley is home to the Timbisha tribe, who have been living in the area for more than 1000 years.

Death valley desert of California

The Gobi Desert

The word 'Gobi' is a Mongolian word, which means "Waterless Place". The Gobi Desert is the world's fifth largest desert and Asia's largest desert. Like the Sahara, the Gobi comprises of three distinct deserts—Taklimakan (Takla makan or Ka Shun) Desert, the Alashan Desert and the Mu Us (or Ordes) Desert. Much of the Gobi is not sandy but is covered with bare rock.

The climate of the Gobi is one of great extremes. There are rapid changes of temperature, not only through the year but even within 24 hours. The rainfall in the Gobi averages 50-100 millimetres. Most of the rainfall occurs in the summer. Temperature range varies from –40 degrees Celsius (in January) to 45 degrees Celsius (in July). Most of the rivers in the Gobi are ephemeral in nature and flow only when rains fall. Rivers

flowing into the Gobi Desert from the surrounding mountains quickly vanish in the dry regions.

The most widely distributed plant in Gobi is the woody and highly drought resistant, saxaul. This almost leaf-less plant grows even in those areas where the sand is unstable and thus helps halt erosion of the soil.

A picture of Gobi desert

Gobi is home to the only remaining Bactrian (or two humped) camels. Some wild asses still roam parts of the Gobi. The extremely endangered Mazzalai or Gobi bear—the world's only desert-dwelling bear— is found here, as are horses, gazelles and ground squirrels.

The Great Basin Desert

The Great Basin Desert covers an area of 409,000 square kilometres. It is the largest desert in USA and is spread over

the states of Oregon, Idaho, Nevada, Utah, Wyoming, Colorado and California. However, the major part of the desert lies in Nevada and Utah. It is a high altitude desert. Most of the desert is at 1200 m above sea level. The Great Basin is not a single basin. It consists of a number of basins. Average annual rainfall in the desert is 250 mm. The vegetation is dominated by saltbush. Among the animals found here are: Great Basin Rattlesnake, the Desert horned lizard and jackrabbits.

The Kalahari Desert

The Kalahari Desert is located in Southern Africa. It covers much of Botswana and parts of Namibia and South Africa. The desert lies between the Orange River in the south and the

A picture of Kalahari desert

Zambezi River in the north. The word "Kalahari" is probably derived from Tswana word 'Keir' meaning the `great thirst', or the tribal word `khalagari' or `kalagare' meaning a `waterless place'. Like many other deserts, the Kalahari Desert is also covered

by sand dunes and gravel plains. The Kalahari dunes are largely fixed and inactive. The sand in Kalahari Desert is mostly fine-grained and it is bright red in some areas and grey in others.

There is a debate whether Kalahari is a true desert or not. Some do not consider it a true desert because some parts of Kalahari receive more than 250 mm of rain. The major portion of the Kalahari Desert is considered as fossil desert. The South West part of Kalahari is truly arid. Temperatures range from 20 to 40 degrees Celsius in the summer. In winter temperature can average below zero degree Celsius.

Animals found in Kalahari include lions, brown hyenas, meerkats, antelope and several species of birds and reptiles. There are more than 400 identified species of plants in the Kalahari but grasses and acacias are the chief vegetation.

There are considerable deposits of coal, diamond, copper, nickel and uranium. The diamond mines located at Orapa in North Eastern Kalahari are one of the largest deposits of diamonds in the world. The nomadic San people live in the Kalahari Desert. The original inhabitants of the Kalahari were called bushmen by the early settlers. Bushmen is the collective name for a number of distinct tribes. They have been living in the Kalahari Desert for more then 200,00 years.

The Kara Kum Desert

The Kara Kum (Black Sands) Desert covers an area of 297,900 square kilometres. It is located in Turkmenistan, east of the southern end of the Caspian Sea and west of the Amu Darya River. The dominant landforms of the Kara Kum Desert are cracked clay surfaces and crescentic dunes. It has an average annual rainfall of 100-200 mm. Temperatures range from –14 to 32 degrees Celsius. Among its chief vegetation are Black saxaul trees.

The Mojave Desert

Mojave Desert (Mohave Desert) is part of the Great Basin of the United States. Mojave Desert, once part of an interior sea, was formed by volcanic action and materials deposited by the Colorado River. The desert is bordered on the north and west by the Sierra Nevada and the Tahachapi, San Gabriel and San Bernardino mountains and merges with Colorado Desert in the south-east. There are intermittent lakes and streams in the Mojave Desert.

Mojave Desert remains warm throughout the year. However, there is a wide temperature variation from day to night. Temperatures range from –13 to 48 degrees Celsius. It receives an average annual rainfall of 50-125 mm, much of it in winter. There is strong desert wind in the afternoon and the evening. The desert has a range of drought-tolerant shrubs. Joshua Tree, a large member of the Yucca family has become a symbol of the Mojave Desert. Among the minerals found in Mojave Desert are borax, gold and iron.

The Namib Desert

Namib Desert is located in Namibia and is believed to be the oldest desert in the world. It has endured arid or semi-arid conditions for at least 80 million years. The Namib Desert was formed by the descent of dry air cooled by the cold Benguela current along the coast of southwest Africa. Its width is less than 160 km and its length is about 1300 km. The desert has active dune systems. Radially symmetrical, star dunes constitute 10 percent of the total dunes found in the Namib Desert.

It receives an average annual rainfall of less than 15 mm. Its chief source of moisture is the coastal fog. The Namib Desert is mostly barren, but it is the home for a number of unusual

species of plants and animals. *Welwitschia mirabilis* found in the Namib Desert is one of the most unusual species of plants found on Earth. This shrub-like plant grows just two long leaves continuously throughout its lifetime. The leaves of the plant may be several metres long and become twisted from the desert wind. *Welwitschia* has developed the ability to survive under the harshest conditions. It derives moisture from the coastal sea fogs. A large number of lichens are found in the Namib Desert. The desert is home to a large number of animals including African elephants.

The Namib Desert is mostly unpopulated and inaccessible. However, there are year-round settlements at Sesriem. The Namib Desert is an important location for mining tungsten, salt and diamonds.

The Negev Desert

The origin of the word Negev is from the Hebrew word denoting 'dry'. The Negev (Negeb) Desert comprises more than half of Israel's land area. It forms an inverted triangle shape whose western side is contiguous with the desert of the Sinai Peninsula, and whose eastern border is the Wadi Arabah. It is bordered by the Jordean Hills, the Sinai Peninsula and the narrow Mediterranean coastal plain. Contrary to the usual view of a "desert," the Negev is not covered with sand. Rather, it is an area dominated by brown, rocky, dusty mountains interrupted by wadis and deep craters. The area actually was once the floor of a primordial sea, and a sprinkling of marine snail shells still covers the surface here. The Negev Desert has considerable deposits of copper, phosphates and natural gas.

The Patagonia Desert

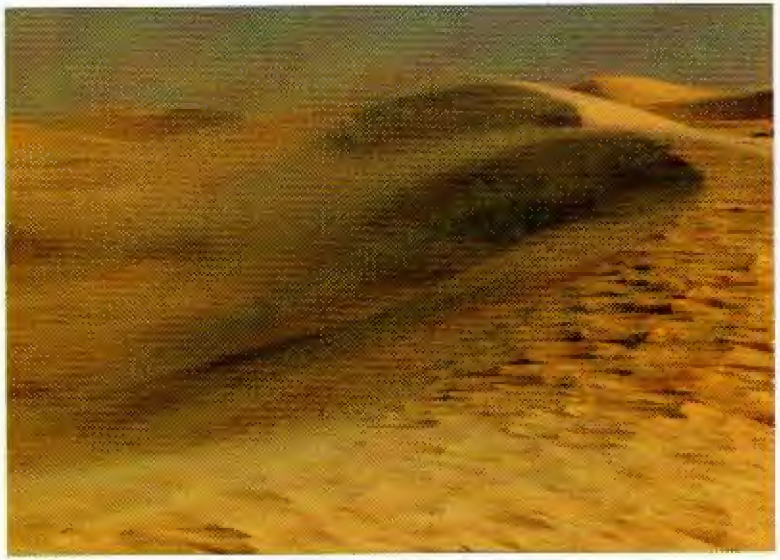
The Patagonian Desert, also known as the Patagonia Desert or the Patagonian Steppe, is the largest desert in the Americas. It

is the 5th largest desert in the world by area, (673,000 km²). It is located primarily in Argentina with small parts in Chile and is bounded by the Andes, to its west, and the Atlantic Ocean to its east, in the region of Patagonia, southern Argentina. The Patagonia is a cold desert. It is a semi-arid region as it lies in the rain shadow of the Andes. Temperatures average only 7 degrees Celsius throughout the year. It has an average annual rainfall range of 100 to 260 mm. The persistent westerly winds in Patagonia are responsible for low vegetation cover because wind-borne dust damages the vegetation. The chief minerals found in Patagonia include coal, natural gas and oil and iron. Among other minerals found in small quantities are uranium, lead and zinc.

The Sahara Desert

The Sahara or the Great Desert is the world's largest hot desert, and second largest desert after Antarctica. At over 9,000,000 square kilometres, it is almost as large as the United States. It covers most of the North Africa. It extends from the Atlantic to the Nile or to the Red Sea. It constitutes half of the world's total desert surface. In Arabic, the word 'sahar' means "desert". The term "Sahara" is plural. Indeed, the Sahara is not one but many deserts. The Sahara is covered by mountains, rocky areas, gravel plains, salt flats and huge areas of sand dunes. From geological evidence it appears that the Sahara was once quite green and parts of the desert were under sea.

The Sahara has one of the harshest climates in the world. In different parts of the Sahara, the average annual rainfall varies from 20 to 400 mm. Parts of central Sahara sometimes get no rains for years at a time. The highest temperature officially recorded was in the Sahara, at a place called Al Aziziyah in Libya, where on 13 September 1922, the temperature reached 58° C. Sahara storms are often localised, affecting an area as small as 20 square kilometres. Strong, unpredictable winds are typical of the Saharan weather systems. These bear names such as khamsin, sirocco, shahali, and simoom and can blow for days on end, bringing with them vast amounts of dust and sand.



Sahara desert

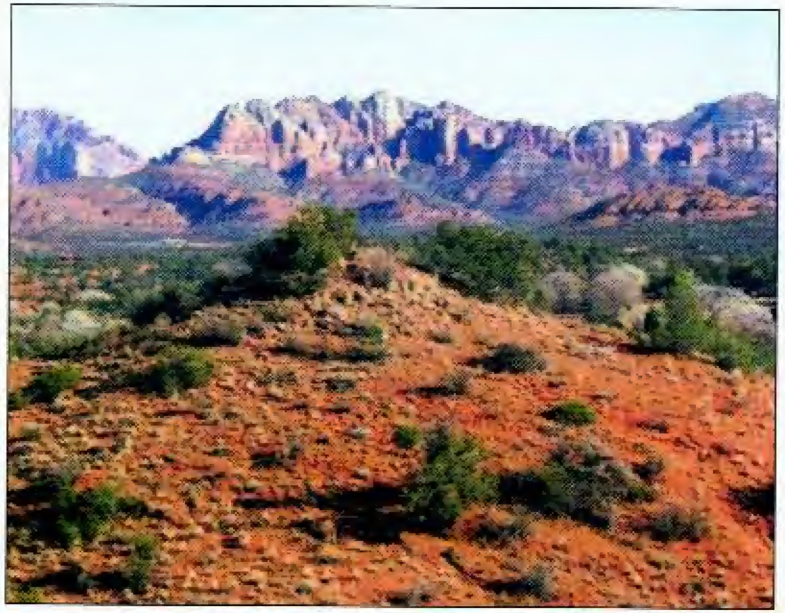
The desert consists mainly of a plateau with central mountain rising to 3415 m and some areas of sand dunes, such as a Libya Desert in the North-East. The landscape of the Sahara Desert is largely moulded by wind-driven processes. The Sahara has undergone a series of wet periods; the most recent occurring 5, 000-10,000 years ago. It was not until 3000 BC that the Sahara was transformed into its present arid state.

The vegetation in the Sahara is sparse but sufficient, in most parts, for the nomads to keep camel, sheep and goat. There are numerous scattered oases to support small communities.

The first European explorers to travel in the Sahara were Friedrich Horneman in 1805 and the Scottish explorer Mungo Park in 1806. But even, now some areas of the Sahara remain virtually unexplored, although a network of air and automobile routes crosses the desert and links the major oases and mining areas.

The Sonoran Desert

The hot Sonoran Desert is located mostly in the state of Arizona, USA and it lies north to the Mojave Desert. Its subregions



Sonoran desert

include the Colorado Desert and Yuma Desert. It covers an area of 275,000 square kilometres. It is one of the largest and hottest deserts in North America. Temperatures range from – 13 to 48 degrees Celsius. It has an average annual rainfall of 250 mm.

Cacti constitute the prominent vegetation. In winter there is spectacular growth of the colourful annual plants, thanks to the winter rains. Plants harbouring nitrogen fixing bacteria in their roots grow here and contribute towards increasing the fertility of the soil. Among the animals living in the Sonoran Desert are lizards including a large species of lizard called the Chuckwalla, desert scorpion and desert tortoise.

The Takla Makan Desert

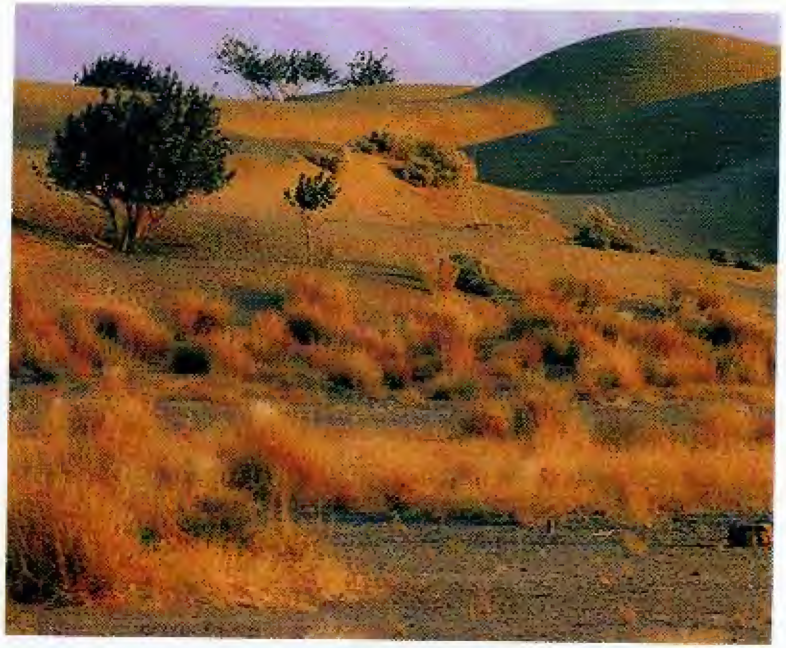
The Takla Makan Desert is located in Xinjiang Province in western China and is China's largest, driest, and warmest desert. It fills the expansive Tarim Basin between the Kunlun Mountains and the Tibet Plateau to the south and the Tian Shan to the north. Located farther from the ocean than almost any place on Earth, this region is completely cut off from the effects of the Asian monsoon. Arctic storms from the north are also blocked by the encircling mountains. Because the basin lacks drainage, salt has accumulated over large areas.

The name "Takla Makan" means "a place of no return". The desert is aptly named as the region is a mixture of dry stony plain and shifting sand dunes. It is the world's largest shifting-sand desert. Eighty-five percent of this ecoregion consists of sand dunes that support very little or no vegetation. It covers an area of 327,000 square kilometres. It has an average annual rainfall range of 40-100 mm. A number of rivers enter the Takla Makan Desert. These rivers are fed by snowmelt from the surrounding snow-capped mountains.

The Thar Desert

The arid Thar Desert is the world's seventh largest desert and is without doubt the most inhospitable ecoregion in the Indo-Pacific region. It is also known as the Great Indian Desert and is located in western India and southeastern Pakistan. The Thar

Desert derives its name from Tharparkar, a district in Pakistan's Sind province. In Pakistan's Punjab province it is known as the Cholistan Desert. It spans approximately 259,000 square kilometres, 69 per cent of which lies in India's north-western region. It is spread over four states in India, namely Punjab, Haryana, Rajasthan and Gujarat. Sixty percent of the Indian Thar Desert is situated in Western Rajasthan. The Thar Desert is part of the Indo-Iranian arid region that stretches from the Caspian



Thar desert

Sea southeast to the Rann Kutch. The Indo-Iranian arid region consists of a number of distinct desert regions and the Thar Desert is one of them. It is separated from other regions by the wide, fertile valleys of the Indus River and its many tributaries.

The Thar Desert is well-known for its high sand dunes. Some sand dunes found in the Thar can reach a height up to

150 metres. Most of the dune systems in the Thar Desert are inactive. There are shifting sands only in some parts of this desert. There are parabolic dunes in the Thar Desert. The occurrence of such dunes in inland deserts is rather an unusual phenomenon. The parabolic dunes in the Thar Desert are created by unusually persistent winds.

The climate is extreme. Annual temperatures can range from near-freezing in the winter to more than 50 degrees Celsius

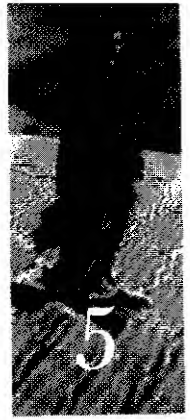
Khejri trees in desert

during summer. Rainfall is associated with the short southwest monsoon (July-September) that brings about 100-500 mm of precipitation. Sand storms are common in May and June and the speed of such storms can be up to 150 km/hr. The mean annual rainfall in the Indian region of the Thar Desert is 345 mm varying spatially from less than 100 mm in the extreme western part to over 400 mm along the eastern fringe. Some

parts of the desert are irrigated by the Sutlej River. No native cactus or palm tree is found. The vast expanse of sand is interspersed by hillocks and sandy and gravel plains.

The Thar Desert is considered one of the most inhospitable landscapes on Earth. But it is also the most populated hot desert of the world. Despite the climate, several species have evolved to survive the extreme conditions here. Among the mammal fauna, the blackbuck, chinkara, caracal, and desert fox inhabit the open plains, grasslands, and saline depressions known as chappar or rann in the core area of the desert. There are more than 20 species each of lizards and snakes in the Thar Desert. Several of these are endemic to the region. Among the birds found here, the great Indian bustard is a globally threatened species. The Khejri (*Prosopis cineralia*) is an important tree in these areas. The importance of these trees can be gauged from the saying that death will not visit a man, even during a famine, if he has a Khejri tree, a goat and a camel, since the three together can sustain a man even under the most trying of circumstances.

Studying deserts makes it amply clear that these are frightening places to be stranded in but fascinating nonetheless.



Desert Landforms

"The conventional image of the desert, however, is neither gravel pavement nor wind-carved mountains, but endless dunes of sand".

David Attenborough in The Living Planet (1984)

A landform is defined as any feature on the Earth's surface such as plain, valley, hill etc., caused by erosion, sedimentation or movement. Deserts display a great diversity of landforms.

The major landforms in the deserts are:

- River-formed landscapes,
- Sand seas,
- Clay plains,
- Stony pavements,
- Lake basins, and
- Plain areas.

Wind-driven processes are major factors in shaping desert landforms and display certain common features. Desert soil is often composed of rocky surfaces called regs. Sand dunes called

ergs and stony or hammada surfaces are less common. Erosion of the surface leads to the removal soil materials till the hard rocks are exposed. And since little, if any, vegetation can be supported by the rocks, such surfaces have almost no green cover.

Sand dunes

In deserts, wind erosion is a powerful force for changing the landscape. The drier the soil, the more effect wind will have, on dislodging soil particles and carrying them away. It is not the power of wind, but the abrasive action of the loose materials that it carries that changes the landscape. In desert there is lot of loose materials in the form of sand grains. Wind erosion is caused by strong winds that physically move lighter, less dense soil particles such as organic matter and clay. Very fine particles are simply suspended in the airstream and carried long distances. Slightly larger soil particles may hop along the surface. Still larger particles are rolled along the soil surface.

Loose soil particles can drift along, bombarding and dislodging still more particles with the same effect as sandblasting. Within about 40 centimetres of the surface of desert sand grains are transported by the wind by the process called saltation. Saltation happens above the windy side of a dune when the sand grains are lifted up into the air. The grains fall back down, hit the sand, and bounce back up. A saltating grain may hit other grains that jump up to continue the saltation. The grain may also hit larger grains that are too heavy to hop, but that slowly creep forward as they are pushed by saltating grains. Surface creep accounts for as much as 25 percent of grain movement in a desert. The speed of sand grains moving in this way is dependent on the strength of the wind and size of the grains.

Sand Dunes

Dunes are most fascinating and complex landforms in the deserts. A dune is a hill of sand created by the wind. The word 'dune' is derived from the medieval Germanic or Norse word `dun', meaning a hill. An area covered by extensive sand dunes is called 'dune field'. The valley or trough between dunes is called a slack. The downwind portion of the dune, the lee slope, is commonly a steep slope referred to as a *slip face*. Dunes may have more than one slip face. The minimum height of a slip face is about 30 centimetres.

On an average dunes cover about 15-20 per cent of the total area of the world's deserts. However, certain deserts (for example Arabian desert) may have much higher percentage of sand dunes. Sand dunes are formed in vast areas of sands called sand seas. The largest single sand sea is the Rub Al Khali in Arabia. It covers an area of about 56,000 square kilometres. The greatest number of sand seas is in the Sahara. It takes thousands of years to form sand seas. Dunes

do not cover the entire area of a sand sea. The dune less areas of sand seas may be undulating plains of sand, or sand sheets, as they are called.

Sand Dune Formation

Dune formation is a complex phenomenon and it is not yet fully understood though there is consensus that three things are required for dune formation to occur:

- A large supply of sand,
- Wind speeds capable of moving it, and
- An ideal location for its accumulation.

Dune formation is a complex phenomenon

It is also agreed that generally dunes form where wind loses energy and drops the suspended sand. Once a sand dune is formed, it ends up replicating itself downward. This happens because of the way a sand dune disturbs the airflow. In this way, dunes of similar height are repeated on a regular pattern. Because they are entirely composed of loose sand, dunes tend to be very fragile, mobile, and susceptible to deterioration and erosion.

The simplest way of dune formation is the accumulation of sands in the leeward side of bushes, rocks or hills. The Drao Malichigdune in Mauritania, which stretches 100 kms long was formed in this way. Dunes are also formed by sudden bursts of strong wind, which create small sand deposits.

Sand Dune Movement

Dunes shift their location and size based on their interactions with the wind. Wind-blown sand moves up the gentle upwind side of the dune by saltation or creep. Sand accumulates at the brink or the top of the slipface. When the buildup of sand at the brink exceeds the angle of repose, a small avalanche of grains slides down the slipface. Grain by grain, the dune moves downwind.

Types of Sand Dunes

There are five basic types of dunes—crescentic, linear, star, dome and parabolic. Different types of dunes occur because of differences in annual wind pattern and sand supply. The different types of dunes range from small ridges of less than 1 metre in height to more than 300 metres in height.

Crescentic Dunes

Half-moon or crescent-shaped mounds of sands are called crescentic dunes. These dunes form under winds that blow from one direction and are also called barchans or transverse dunes. Generally crescentic dunes are more wide than they are long. Some types of crescentic dunes move faster over desert surface than any other type of dunes. The largest

crescentic dunes are found in Takla Makan Desert of China. They have a mean crest-to-crest width of more than 3 kilometres.

Linear Dunes

Straight or slightly sinuous sand ridges are called linear dunes. They are typically much longer than they are wide. Their lengths may extend more than 160 kilometres. They generally occur as sets of parallel ridges separated by kilometres of sand, gravel or rocky inter dune corridors. These may also occur as isolated ridges. Sometimes linear dunes may merge to form Y-shaped dunes.

Parabolic Dunes

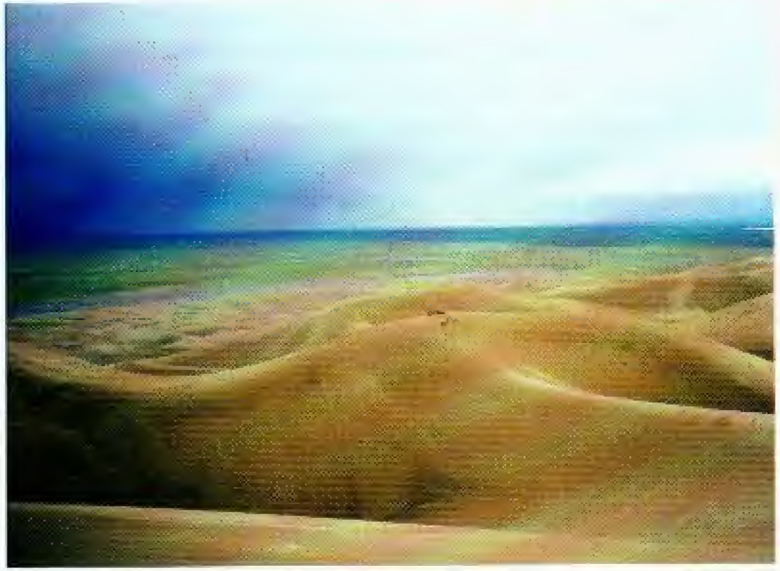
Parabolic dunes are U-shaped mounds of sands with convex noses trailed by elongated arms. They are also called U-shaped, blow-out or hairpin dune. Their crests point upwind. Parabolic dunes are a notable feature of the Thar Desert and many coastal deserts.

Dome Dunes

Dome dunes are oval or circular mounds of sands. They generally lack a slip face. They occur at the far upwind margins of sand dunes. Dome dunes are rare.

Star Dunes

Star dunes are formed when the direction of the wind is variable throughout the year. Star dunes are pyramidal in shape and long, sinuous arms radiate from the summit. Star dunes are found in abundance in Grand Erg Oriental of the Sahara. Star dunes found in other deserts occur around the margins of the sand seas. Some of the tallest star dunes are



Star dunes

found in Badain Jaran Desert of China. They reach a height up to 500 metres.

Reversed Dunes

The basic forms of dunes may occur in reverse forms too. Such reversion occurs when there is reversion in wind direction. Such dunes have major and minor slip faces oriented in opposite directions. There may be varieties of any one of the five basic types of dune shapes.

All the five types of dunes may occur in three forms—simple, compound and complex. When a particular type of dunes occurs in its basic form, it is called simple dune. Compound dunes are large dunes on which smaller dunes of similar type and slip face orientations are superimposed. Complex dunes are combinations of two or more dune types.

If the wind direction is fairly uniform over the years, the dunes gradually shift in the direction of the prevailing wind. The occurrence of simple dunes indicates that a wind regime has not changed in intensity or direction since the formation of the dune. But the occurrence of compound and complex dunes indicates that a wind regime has changed in intensity and direction.

Threats to Sand Dunes

- Sand mining.
- Human development occurring within the dunes including road construction.
- Introduction of exotic plants and animals (including farm animals) which invade and displace native plants or feed on these.
- Damage and destruction of dune vegetation by tourist vehicles.
- Damage to dune vegetation from foot traffic, and 'dune surfing'.

Sculpting Landscapes

Eolian processes pertain to the activity of the winds and more specifically, to the winds' ability to shape the surface of the Earth and other planets. The term "Eolian" is derived from the name of the Greek god, Æolus, the keeper of the winds.

Since winds erode, transport, and deposit materials, they are effective agents in regions with sparse vegetation and a large supply of loose sediments. Wind-driven process is the most dominant force in shaping desert landscape. But there are other forces in action too. Running water, though not a very common phenomenon in deserts, plays a significant role in shaping landscapes. The most distinctive desert landscapes

created by running water are badlands—areas dissected by dense networks of rills and deep-sided gullies.

Yardangs

Yardang is a word of Turkish origin, meaning 'steep bank'. These are elongated, tapering, streamlined bedrock hills eroded by wind. Typically these hills have high, blunt forward ends that face the prevailing wind, and they become lower and narrower to lee ward. Yardangs or wind-sculpted hillocks are the result of the large-scale wind erosion and are commonly found in corridors of sand movement where high winds hurl the sand grains against the rock faces. Yardangs form in places where water is scarce but prevailing winds are strong, unidirectional and carry an abrasive sediment load. The wind cuts down low lying areas into parallel ridges. These gradually erode into separate hills that ultimately form a field of yardangs, commonly referred to as a fleet because they resemble the bottoms of ships. Yardangs may take hundred of thousand years to form. These are aligned parallel to the direction of the wind. Yardangs are usually curved from soft, loose rocks but there are examples, like Tibesti Yardangs, which are cut in hard sand stones.

Blowouts

Wind can be effective agent of erosion anywhere that it is strong enough to act. Wind can erode by deflation. Deflation is the lowering of the land surface due to removal of fine-grained particles by the wind. Deflation concentrates the coarser grained particles at the surface, eventually resulting in a surface composed only of the coarser grained fragments that cannot be transported by the wind. Such a surface is called desert pavement. Large semicircular, elongated hollows called Deflation basins, or simply, blowouts, are often created by wind

erosion. Blowouts are generally small, but may be up to several kilometers in diameter and are usually devoid of vegetation.

Salt flats

Salt flats or salt pans are important desert landforms. These are flat expanse of ground covered with salt and other minerals. A salt pan marks an area where water accumulated, and

Salt flats

evaporated leaving behind the dissolved minerals. Over millennia, the minerals (usually salts) accumulated on the surface to form a dazzling white encrustation over a quagmire of mud. The Bonneville Salt Flat is a well-known salt pan in the arid regions of western USA.

Weathering Away

Weathering is the process of breaking down rocks, soils and their minerals through direct contact with the atmosphere.

Weathering occurs 'without movement', and thus is distinct from erosion, which involves the movement and disintegration of rocks and minerals by agents such as water, wind etc. Weathering is also an important factor in shaping landscapes. Weathering makes rocks disintegrate. Sometimes weathering processes create very unusual landforms like towers of resistant rocks.

Inselbergs

Inselbergs are among the larger landforms of deserts created by weathering. These are the remains of long-eroded mountain ranges and stand out as isolated hills above the flat desert surface. Australia's Uluru (also called Ayers Rock) is a fine example. Spectacular granite inselbergs can be seen in the Namib Desert .

Mesa and Bust

Mesa is a steep-sided eroded remnant of a plateau. It is a desert landform. The name Mesa pays tribute characteristic table-top shape as the word is Spanish and Portuguese for "table." Mesas form in areas where horizontally layered rocks are uplifted by tectonic activity. Variations in the ability of different types of rock to resist weathering and erosion cause the weaker types of rocks to be eroded away. This leaves the more resistant types of rocks elevated in respect to the surrounding eroded landmass. This process is called differential erosion. A small mesa is usually called bust.

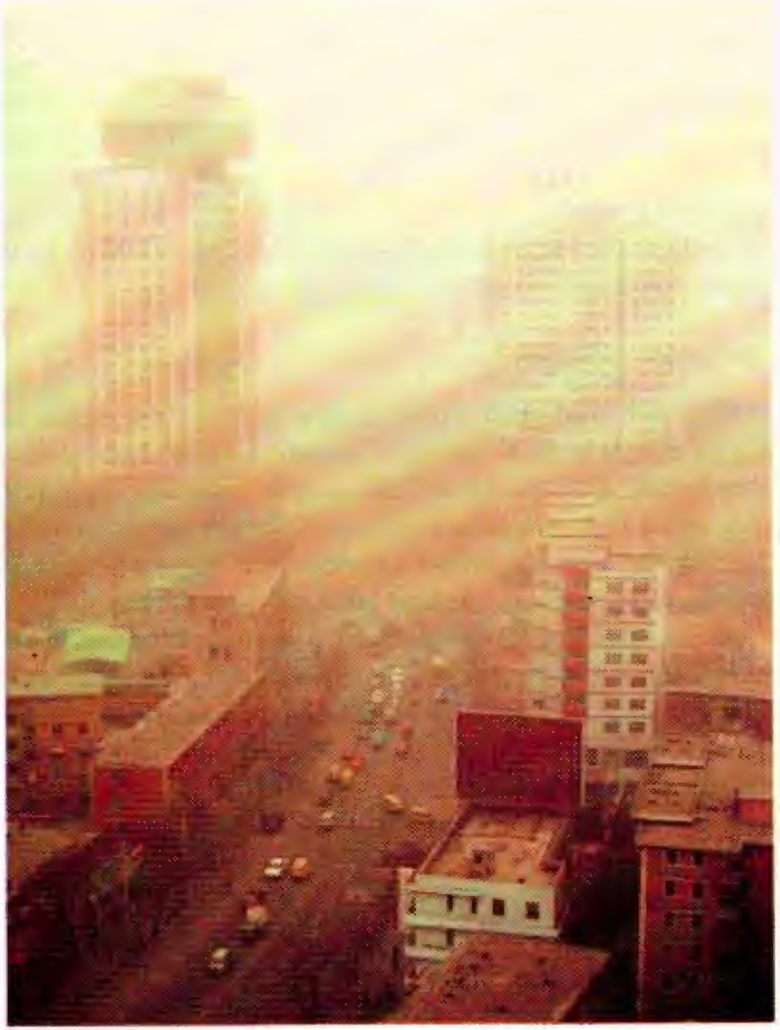
Deserts as Dust Factories

Deserts are the largest 'factories' for producing dust. Dust storms are created when dust is carried by winds. They usually occur when the wind is strongest and so are highly seasonal in occurrence.

A sandstorm can move whole sand dunes. Dust storms can carry large amounts of dust, so much so that the leading edge of one can appear as a solid wall of dust as much as 1.6 km high. Arid- and semi-arid areas produce more dust than the hyper-arid areas. This is because dusts are formed when wind and water act together. So there is less dust in hyper-arid areas because there is hardly any rainfall there. Agricultural processes are affected by dust storms. Crop damage is a common problem, but the main concern is the associated erosion that takes place. With the blowing away of precious top soil, eventually an area can become barren and then it could even become a desert. For example, the massive dust storm hit east Australia in 2002 and which raged across drought-ravaged farmland in Queensland and New South Wales states was estimated to have carried away tens of millions of tonnes of precious topsoil. Drought, poor farming techniques and grazing practices exacerbate the situation by exposing the dust and sand to the wind.

Saharan Duststorms

The Sahara Desert alone produces somewhere between 60 to 200 million tonnes of dust annually. Dust and sand storms which come off the Sahara Desert are locally known as a simoom or simoon. The Sahara is the major source of mineral dust (60-200 millions of tonnes per year). Every year windstorms across the Sahara Desert blow hundreds of millions of tons of dust high into the sky over North Africa. Depending on the season, the dust may be blown across the Mediterranean Sea into Europe or over the Atlantic Ocean. Saharan dust can be lifted by convection and can thus reach very high altitudes. From there it can be transported worldwide by winds. The dust combined with the hot dry air of the Sahara Desert often forms an atmospheric layer called the Saharan Air Layer. This layer has significant effects on tropical weather.



Duststroms

Dust storms can cover vast area and sometimes the consequences can be felt in areas quite remote from the place where the dust storm has raged. For example, in a study funded by NASA, surprising evidence has been found for a connection between dust from the Sahara and fish kills far away. Storm

activity in the Sahara Desert region generates vast clouds of dust that the Easterly trade winds carry across the Atlantic Ocean and into the Gulf of Mexico. The iron-rich dust fertilizes the water off the West Florida coast. When iron levels go up, bacteria, called *Trichodesmium*, fix nitrogen in the water, converting it to a form usable by marine life. The availability of biologically usable nitrogen encourages the growth of toxic algae, which in turn kills the fish feeding on it.

Asian Duststorms

Asian Dust (also yellow dust, yellow sand, yellow wind, or China dust storms) is a seasonal meteorological phenomenon which affects much of East Asia during the spring. The dust originates in the deserts of Mongolia, northern China and Kazakhstan where high-speed surface winds and intense dust storms kick up dense clouds of fine, dry soil particles. These clouds are then carried eastward by prevailing winds and pass over China, North and South Korea, and Japan, as well as parts of the Russian Far East. Sometimes, the airborne particulates are carried much further, in significant concentrations which affect air quality as far east as the United States.

Resources from Deserts

> "Most of the industry in deserts is based on extracting hydrocarbons and minerals. Apart from a small number of enterprises, such as tourism and film-making, that can gain some advantage from the climate, deserts often offer few other positive attractions to industrialization".
>
> *Deserts: The Encroaching Wilderness (A Mitchell Beazley World Conservation Atlas), Tony Allan and Andrew Warren (General Editors)*

The world's deserts are generally remote, inaccessible, and inhospitable. However, there is hidden wealth here in the form of hydrocarbon reservoirs, and mineral deposits. Human artefacts are also preserved, for centuries, in deserts largely because of their arid climate. The Atacama Desert of South America is unique among the deserts of the world in its great abundance of saline minerals.

Mineral Deposits

Mineral deposits are natural accumulations of one or more useful minerals. Mineral deposits are the source of many

important commodities, such as copper and gold. These deposits are a nonrenewable resource. Once mined, they are exhausted, and another source must be found.

New mineral deposits are being continuously created by the Earth but may take millions of years to form. Some mineral deposits are formed, improved, or preserved by geologic processes that occur in arid lands as a consequence of climate. Evaporation in arid lands enriches mineral accumulation in their lakes called Playas.

Minerals from Playas

A playa is a dry, vegetation-free, flat area at the lowest part of an undrained desert basin. It is a location where lakes form only during wet periods and dry out afterwards. Playas are underlain by stratified clay, silt, and sand, and commonly, soluble salts. Between wet periods the surface of the playa typically completely dries out and cracks and fissures appear as clay-rich sediments dry out. Playas typically form in closed basins. Water evaporating in such closed basins precipitates minerals such as gypsum, salts (including sodium nitrate and sodium chloride), and borates. Water-soluble salts, which readily accumulate in desert deposits due to the ambient dryness, such as gypsum, borates, table salt, and sodium and potassium nitrates, have been historically a product of deserts.

The minerals formed in these evaporite deposits depend on the composition and temperature of the saline waters at the time of deposition. The dry Soda Lake in the Mojave National preserve is a good example of a playa. During dry periods, alkali salts, primarily sodium carbonate and sodium bicarbonate, form a frothy-white coating on the surface.

Metallic Ores

Considerable amounts of metallic ores are found in many deserts. Copper, iron, gold, silver, and uranium ores are found in the deserts. Most of the copper of the world comes from the edges of the Atacama in South America and from Sar Chesmah in the high salt deserts of the Iranian Zagros Mountains. The parts of Sahara in Mauritania and south-western Algeria and the Dasht-e Kavir Desert have considerable reserves of iron ores. Deserts of Australia, United States and Namibia have large reserves of uranium. The Diamond Coast, Namibia's richest reserve of diamond is located in Namib Desert.

Non-metallic Deposits

Non-metallic mineral resources and rocks such as beryllium, mica, lithium, clays, pumice, and scoria are also found in arid regions. Sodium carbonate, sulphate, borate, nitrate, lithium, bromine, iodine, calcium, and strontium compounds come from sediments and near-surface brines formed by evaporation of inland bodies of water, often during geologically recent times. The biggest deposits of sulphates in the world are found in the deserts. The world's largest deposits of phosphates are located in deserts particularly in the Sahara and Jordanian deserts. Two large potash industries are located in the Dead Sea, one of the hottest deserts of the world. The saltpetre and salt beds of the Atacama Desert, contain 40 per cent of the world's reserves of lithium, used in medicine and industry.

Importance of Desert Minerals

The importance of the mineral deposits in the deserts across the globe can be summarized in this quote from the United Nations Environment Programme (2006) (http://www.unep.org/GEO/gdoutlook/049.asp): "Thirty-eight percent of the global supply of bauxite (an aluminium source)

is mined in Australian drylands. Fifty-two per cent of the world's copper extraction in 2004 was mined from deserts in Chile, Australia and Mexico; 33 per cent of the world's diamonds were extracted in the drylands of Botswana and Namibia; and the deserts of South Africa, northwest China, Australia, Uzbekistan, and Mali accounted for at least 35 per cent of the world's production of gold. Twenty per cent of global iron ore production and 35 per cent of its exports came from Australia, where many mines are located in the desert. Phosphate rock is mined in the deserts of Morocco (16 per cent of world production), Senegal (9%), Tunisia (6%), Jordan (5%), Australia (4%), and Israel (3%), adding up to 43 per cent of global production. Finally, half the world's uranium ores are mined in deserts (Kazakhstan, Niger, Namibia, Uzbekistan, South Africa; BGS 2006). The most important contribution of deserts to mineral wealth is their deposits of evaporite minerals - soda, boron, and nitrates (e.g., Chile saltpetre), which are not found in other ecosystems".

Solar Energy

Solar energy arrives on Earth at a maximum power density of about 1 kilowatt per square meter. Deserts receive abundant sunlight and are thus ideal candidates for producing renewable solar energy. Solar thermal power plants (Concentrating Solar Power Plants or CSP plants) produce electricity in much the same way as conventional power stations but they obtain their energy input through concentrated solar radiation. Then they convert it to high-temperature steam or gas to drive a turbine. It has been estimated that a solar thermal power plant built on about 1% of the surface of the Sahara Desert would be sufficient to satisfy the entire world's electricity demand.

However, solar "productivity" is limited by certain geographical factors, including cloud cover and atmospheric

humidity. In sunny, arid locations, one square kilometer of land can generate as much as 100 gigawatt hours (GWh) of electricity per year using solar thermal technology, enough power for 50,000 households. The world's largest solar power plant at Luz is located in the Mojave Desert, California, USA.

Deserts are important sources of non-renewable energy

Saline Minerals

The Atacama Desert of South America has saline minerals in great abundance. Sodium nitrate has been mined for explosives and fertilizer in the Atacama since the middle of the 19th century. During World War I alone nearly 3 million tones of sodium nitrate were mined in the Atacama Desert. Common salt is mined in many deserts.

Bio-Resources

It is thought that desert plants can be the source for chemicals that may be derived or extracted for medicinal use, since these plants have adapted to thrive in hostile conditions. Deserts are home to large numbers of medicinal and herbal plants

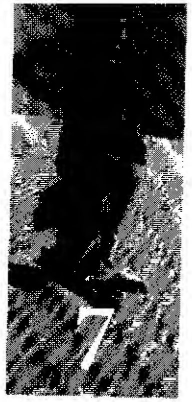
traditionally used by desert and non-desert people - for example, 95 per cent of disease treatments of the Thar Desert are provided through the use of 85 desert plant species. Indeed, recent screening of plants in the Negev Desert has led to the identification of a few species with anti-malarial activities. Some plant species from deserts in Argentina, Arizona and Morocco have shown activity against infectious microbes.

Aloevera source of medicine

Many countries with large deserts, such as China and India, export herbal and medicinal plants.

Unfortunately, none of the known active compounds of desert plants have been developed to the level of a certified pharmaceutical in worldwide clinical use, though there are several patented claims for medicinal properties of such compounds. There is at least one dietary supplement derived from a dryland plant (*Hoodia gordonii*—a cactus from the Kalahari Desert) that is commercially marketed.

The pharmaceutical potential of desert plants remains to be fully exploited, though it must be emphasized that desert ecosystems are fragile and over-harvesting may have disastrous consequences for the plant populations in the wild.



Water in Deserts

"In semi-arid and arid climates, there is by contrasts practically no exchange between the surface water and groundwater regimes because the small volume of seepage from the occasional rainfall only rarely penetrates the thick and dry (unsaturated) soils. In these areas groundwater resources are only minimally recharged. These differences must be considered in any concept of regionally integrated water resource management".

Groundwater—Reservoir for Thirsty Planet, Earth Sciences for Society Foundation, Leiden, The Netherlands, 2005

The most sought after commodity in deserts is water. Except on some occasions, when there are torrential rains in some parts of the deserts, demand for water far exceeds the supply. Lack of water creates a survival problem for all desert organisms, animals and plants alike but those who have made deserts their home, know how to preserve water and to suck it from far below the ground or from the air.

Rainfall

Little, if any, rains fall in deserts. Not only does rain seldom fall in deserts, it comes unexpectedly and often several years might pass before the place is wet by another much-awaited spell of rainfall. Often evaporation exceeds rainfall rates. Dry, hot air of the deserts removes water very quickly by evaporation. Sometimes rain starts falling and the water evaporates before reaching the ground.

There is a difference in the amounts of precipitations received by hot and cold deserts. Hot deserts usually have very little rainfall and/or concentrated rainfall in short periods between long spells of droughts. Compared to hot deserts, there is more rainfall in cold deserts though much of the water is tied up as ice. Average annual rainfall in deserts is less than about 250 mm. In some desert regions rainfall may be exceedingly low. The Atacama is the Earth's driest desert. In the Atacama, measurable rainfall—1 millimeter or more of rain—may occur as infrequently as once every 5-20 years. The average annual rainfall in Atacama is less than 1.5 cm. The interior parts of the Sahara also receive less than 1.5 cm a year. But when it rains, the deserts come alive—they flower! In deserts, rainfall events trigger short periods of high resource abundance, as if Nature celebrates the brief duration of the rains with an abundance and exuberance rarely matched elsewhere. Rainfall pulses are really the driving force structuring desert ecosystems.

Rivers and Streams

Deserts receive runoff from short-lived streams. Since the streams are short-lived these are referred to as ephemerals. The beds of such rivers and streams normally remain dry but occasional heavy rains may cause flash floods, which can be highly destructive. Some of the world's largest river systems

pass through arid regions—Murray-Darling in Australia, the Rio Grande in North America, the Indus in Asia and the Nile in Africa, being examples. These rivers are called "exogenous" or "exotic", because their origins lie outside the arid zone. Exotic rivers provide water for plants and wildlife in deserts. Large amount of water of these rivers are lost by evaporation on their journey through the deserts. However, their volumes are such that they maintain their continuity.

Rivers, which originate in deserts, are called endogenous rivers. The sources of endogenous rivers are groundwater springs. Ground water is stored in porous rocks or in cavities of rocks or unconsolidated sediments. Endogenous rivers regularly flowing through deserts do not often reach the seas but they end up in inland basins.

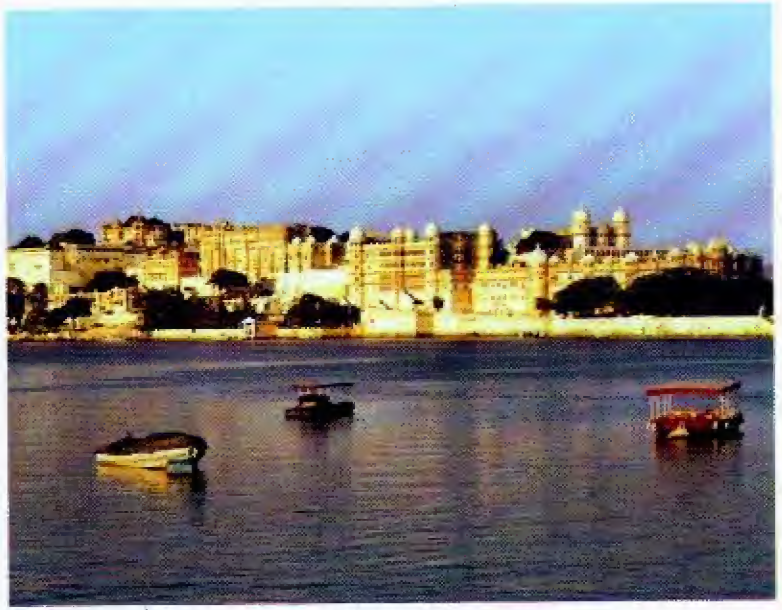
Life in the deserts depends upon the rivers that flow through these areas and which are constantly changing between states of flood and drought. Rivers in dry regions of the world are the poor cousins in the knowledge base of river and wetland ecology. Their ecology is probably the least known of our freshwater resources, partly because of the harshness of the terrain and climate, which deters all but the most stout-hearted of researchers.

Lakes

Paradoxical as it may sound, there are lakes in deserts. Lakes form where sufficient rainfall or melt-water accumulates in interior drainage basins. However, desert lakes are generally shallow, temporary and salty. When desert lakes dry up, they leave a salt crust or hardpan.

An endorheic basin—also called a terminal or closed basin—is a watershed from which there is no outflow of water. Any rain that falls inside such a closed basin may

only leave the system by evaporation. Although endorheic basins can occur in any climate, in practice they are most commonly found in hot desert locations. In hot deserts, the net inflow is low and loss to solar evaporation high, coupled to this is the closed nature of this water flow. All these lead



Udaipur lake

to the concentration of salts and other minerals in the lake. Minerals leached from the surrounding rocks are deposited in the basin, and left behind when the water evaporates. Thus endorheic basins often contain extensive salt pans (also called salt flats, salt lakes, alkali flats or playas).

Lakes that form in endorheic basins can be permanent or temporary. Even permanent endorheic lakes change size and shape dramatically over time, often becoming smaller (or breaking into several smaller parts) during the dry season.

One of the few endorheic lakes in a cold desert location, Antarctica's Lake Vida remains liquid because its salinity is seven times that of seawater.

Groundwater

It has been estimated that about 10,000,000 cubic kilometres of water is stored underground. This is 200 times the global annual renewable water resource provided by rain. The water stored underground is called groundwater. There is groundwater in deserts. Most of the groundwater probably accumulated in the past 100, 000 years.

The discovery of groundwater reserves in the Middle East, Central Asia and North Africa was made during the search for crude oil which began in the 1930s. The United Nations Environmental Programme (UNEP) and the World Bank have made attempts to survey groundwater in deserts and to develop suitable technologies for extraction of groundwater.

The groundwater is stored in aquifers or water-saturated rocks/sediment. A formation of rock or soil is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces become fully saturated with water is called the water table. Groundwater is naturally replenished by surface water when this recharge reaches the water table. Waters stored in deep aquifers are called "fossil" waters. Such water has been stored for thousands of years and the aquifers storing fossil water are no longer being recharged. The distribution of groundwater is highly uneven and the most of it is stored at great depths. Groundwater eventually flows to the surface naturally and in deserts can form oases.

Unlike in the wetter parts where there is high rainfall and large volumes of water seeps into the groundwater, there

is hardly any exchange between the surface water and ground water regimes in deserts and/or arid regions.

In deserts, there is only occasional rainfall and the water reaching the desert surface does not often penetrate much through the dry soil. So the groundwater in arid regions are only minimally recharged. Groundwater is a highly useful and abundant resource, but in arid or semi-arid regions it is in a pre-development state. Thus the increasing use of groundwater for irrigating marginal farmland in arid and semi-arid regions may totally deplete it. While it cannot be denied that extraction of groundwater is unavoidable, it is equally true that adequate planning and care must go into its use. There has been inadequate attention to water conservation, efficiency in water use, water re-use, groundwater recharge, and ecosystem sustainability. An uncontrolled use of the borewell technology has led to the extraction of groundwater at such a high rate that often recharge is not sufficient. Modern technology has made its possible to lift groundwater from depths as great as 500 metres. This is a recipe for disaster, particularly in desert ecosystems, although it may have allowed cultivation to take place on an enhanced scale. For example, in Saudi Arabia, hundreds of thousands of hectares of land have been brought under agriculture by utilising the groundwater of the Riyadh region.

This consequence of the large-scale cultivation on desert lands is extensive degradation of the deserts in many areas of the world. Groundwater does not respect political boundaries and so pumping in one country can dramatically alter the water table in another. This calls for international cooperation with adequate governmental and legal institutional framework for just and equitable management of groundwater.

Desert Fog

Fog is an important source of moisture in some deserts such as the Namib and parts of Atacama. These deserts receive moisture equivalent to as much as 130 mm of rain from the fog that desends here. The fog brings the moisture necessary to sustain life. In the Namib, the fog extends inland for tens of kilometres on most mornings. Any small irregularity (like a stony outcrop) on the landscape causes the fog to condense and droplets of water are deposited. When the 'fog-water catchment' is large enough the wildlife supported may even be called luxuriant. So reliable and so generous is the desert fog that humans have harnessed it as a source of drinking water. This was first implemented in the mountains of the arid coastal desert of northern Chile in 1987.

Desert fog

Dew

Dew is a modest but much appreciated source of water in arid and desert regions. Dew is water in the form of droplets that appears on exposed objects in the morning or evening. As the exposed surface cools by radiating its heat, atmospheric moisture condenses at a rate greater than that of which it can evaporate, resulting in the formation of water droplets. The role of dew in arid and semi-arid ecosystems is considerable as it serves as a water source for the bacteria, plants and small insects. More importantly it sustains biological activity leading to crust formation on sand dunes. These crusts help to stabilize the dunes and are of inestimable importance in desert ecosystems. In the Negev Desert of Israel dew falls on about 200 days each year.

Snow

Snow is a type of precipitation in the form of crystalline water ice, consisting of a multitude of snowflakes that fall from clouds. In some deserts the main source of water is the winter snow. Such deserts have very cold winters. The water equivalent of the snow is thickness of the layer of water having the same content. For example, if the snow covering of a given area has a water equivalent of 30 cm, then it will melt into a pool of water 30 cm deep covering the same area. The largest cold desert is Antarctica , composed of about 98 per cent thick continental ice sheet and 2 per cent barren rock.

Oasis

The word "oasis" is believed to come from an ancient Egyptian word, "wah," meaning "fertile place in the desert". Desert oases (singular: oasis) are fertile places where there is reliable supply of water. An oasis develops around natural permanent springs, where water comes from water-saturated rocks or aquifers. An

Oasis

oasis is actually a spot in the desert where the water table is right underneath the surface, resulting in the presence of springs. Human settlements in deserts cluster around oases and most well-travelled desert paths lead the thirsty travellers to one. There is usually lush growth of plants in the area around an oasis. In many places palm trees are a prominent feature. It is clear that though dryness is the most significant environmental factor in a desert; nature has provided enough sources of water for life to be sustained and it does!

8

Desert Plants

"Desert plants are generally of two main types: ephemeral annuals, which survive arid conditions as seeds, and perennials, which continue to survive and cope with periods of water scarcity."

Earth, James F. Luhr (Editor), Dorling Kindersley Ltd., 2003.

Deserts are far from being good habitats for plants, characterized as they are by intense light as well as high temperatures. Intense light and high temperatures can affect cellular biochemistry deleteriously. So both are dangerous for the plant's survival. However, the most serious problem for plant's survival is the lack of water in deserts. There is a concomitant high rate of evaporation, so the conservation of water and its proper use is one of the greatest challenges faced by desert plants.

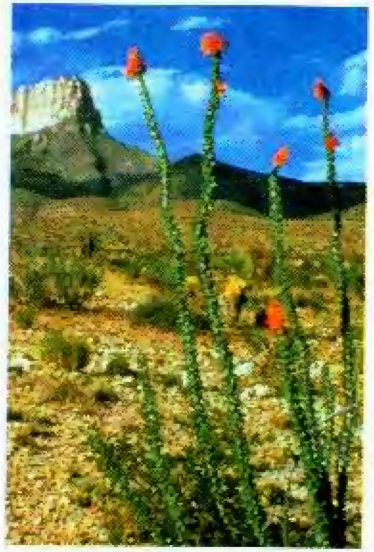
Plants inhabiting deserts are called xerophytes or dryland plants. Desert plants have developed three main adaptive

strategies: succulence, drought tolerance and drought avoidance to survive. Each of these is a different but effective set of adaptations for prospering under conditions that would kill most other plants.

Desert plants have been classified into three kinds depending on the mode they have evolved to use to survive the harsh conditions. The plants are called : Evaders, Avoiders, and Tolerant.

Evaders

Evaders, as their name suggests, by-pass the drought period as seeds. However, they germinate the moment rain falls. The growing plant establishes swiftly taking maximum advantage of the transient ambient conditions. These bloom quickly, swiftly set seed which ripen in a few days. The plant then withers and dies. But the seeds remain—ready to germinate when it rains again. The evaders are also called ephemerals. These ephemerals sometimes live for only a few days. Their seeds or bulbs can lie dormant in the soil for years, until a heavy rain enables them to germinate, grow, and bloom.


Evaders

Avoiders

The avoiders are those, which avoid water loss by developing special structural modifications. For example, succulent plants and cactus can store water in the specialized tissues of plant

cells called vacuoles. Some desert plants can also survive extreme dehydration and then rehydrate when water is available with little or no damage to the cells.

Tolerant

Tolerant plants are perennials that is they have become accustomed to thriving in desert environments. Drought tolerance refers to a plant's ability to withstand drying without dying. Plants in this category often shed leaves during dry periods and enter a deep dormancy. Most water loss occurs by the process of transpiration through leaf surfaces. So dropping leaves conserves water in the stems. Some plants that do not normally shed their leaves have resinous coatings that retard water loss. The roots of drought tolerant plants are more extensive compared to those of plants in wetter climates. Thus the plant can access the soil at greater depths for water.

Most of the desert plants are drought or salt tolerant. The truly drought-tolerant plants are lichens (a functional assemblage of algae and fungus), ferns, and some seed plants. Such plants, which can withstand dehydration for long periods of drought without succumbing to it, are collectively called resurrection plants. These plants become dry and appear dead when there is no water but revive when they get water.

Plants belonging to the Family *Chenopodiaceae*, can survive high salinity. Such plants are called halophytes. The Atriplex species of the family *Chenopodiaceae*, collectively called the saltbush, has the amazing capacity to survive on saline soils.

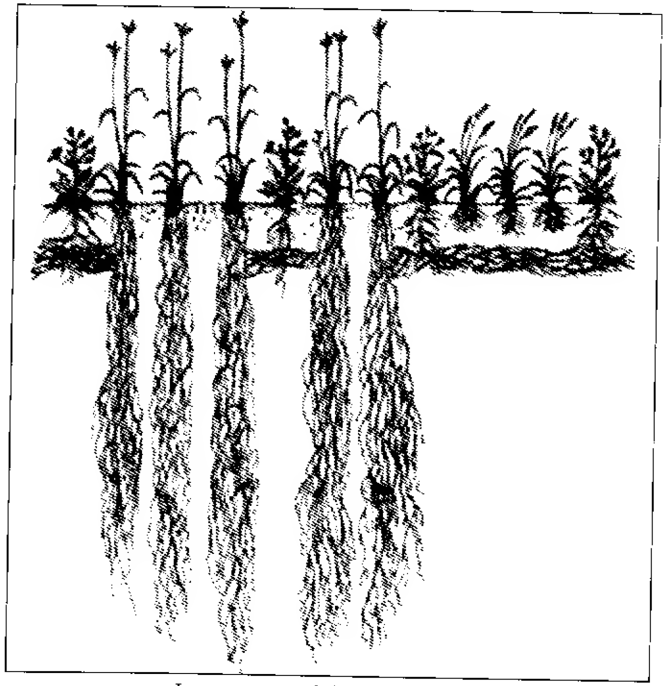
Adaptations

Cacti are synonymous with deserts but there are also other types of plants that have mastered the art of thriving in the arid environment. Among the non-cacti plants are the pea and

sunflower families. Grasses and shrubs are the dominant vegetation in cold deserts. All desert plants show two main adaptations; both linked to survival. These are:

- Ability to collect and store water
- Features that reduce water loss

Desert plants have evolved these life-saving adaptations over millions of years. The adaptations are of three types, namely, morphological, physiological and anatomical.



Long roots of deserts grasses

Some examples of the adaptations include development of roots that grow 3 to 6 times the height of the visible stem in their attempt to reach underground water. Other desert plants, in their attempt to catch the moisture from light showers, have

developed a network of fine roots called 'rain roots' that spread out just below the surface of the ground. In some desert plants the leaves have been reduced in size to control water loss by transpiration. In some cases, the leaves have become so tiny that they are incapable of supporting the plants through photosynthesis. The stems of such plants are green and photosynthesis therefore, takes place in the green stem itself. Examples include: *Euphorbia caducifolia* (Thar Desert), *Fouquieria splendens* and *Opuntia sp.*, (Sonoran Desert).

Succulent plants store water in their leaves, stems and/ or roots. It may be said that these plants make use of their stems and branches as storage bags for water. Succulence of the parts that lie above the ground is a common feature of desert plants. The succulents are categorised as leaf succulents, stem succulents, root succulents and stem & root succulents depending on where they store water. Succulents can absorb large amounts of water during a heavy rain and can store it for a long time. The Saguaro cactus (*Carnegia gigantean*) of the Sonoran Desert can collect as much as one ton of water after one or two showers of heavy rain. This is possible because of the large size of the Saguaro cactus, which reaches a height of 15 m and weighs 9-10 tonnes.

Leaf Adaptations

Desert plants also have thick waxy cuticles or resins covering the surface of their leaves or stems. This minimizes water loss. The spiny nature of many desert plants helps the plants to withstand the heat. The large number of spines shades the plant surface enough to significantly reduce transpiration. The hairs and spines on desert plants cast minute shadows on desert plants, which can protect them from the sun. Silvery or glossy leaves of desert plants allow them to reflect more radiant energy and this helps keep the plant cool. Hair on the leaves helps

reduce the evaporation of moisture by reflecting sunlight and inhibiting air movement. And of course, hairs and sharp spines deter hungry herbivores.

The loss of water through stomata, or the microscopic pores found on the under side of leaves, is referred to as transpiration. Compared to plants in wetter areas, desert plants have a lower density of stomata in their leaves.

Euphorbia Caducifolia drop their leaves during dry periods

Most desert plants have small or rolled leaves to reduce the surface area from which transpiration of water can take place. Others drop their leaves during dry periods. Most desert plants have small leaves or no leaves at all. The smaller or fewer leaves a plant has, the less water it loses by transpiration since it has less surface area exposed to the Sun and wind. However, in this process the number of stomata is also reduced. This has certain physiological implications for the plant.

Photosynthesis is the process by which plants make food (in the form of sugar) from Carbon dioxide and water in the presence of sunlight. The stomata permit Carbon dioxide to enter the plant, and they also allow oxygen, a by-product of photosynthesis, to exit.

The succulent plants solve the problem of water conservation by opening their pores only at night. Temperatures are low at night and so the loss of water through evaporation is reduced. This leads to the problem of balancing two needs. While closing the stomata during the hottest part of the day and opening them only for a short while at night solves the need for water conservation, it throws up the

Opuntia plant have all possible adaptations to survive in deserts

challenge of balancing Carbon dioxide uptake. At night plants can absorb Carbon dioxide through the pores, but there can be no photosynthesis in the absence of sunlight. The desert plants

overcome this problem by storing the Carbon dioxide absorbed at night and using it during the day for photosynthesis.

This process of using Carbon dioxide stored at night for photosynthesis during the day was first detected in the succulent Family *Crassulaceae* and it is known as Crassulacean Acid Metabolism or CAM photosynthesis.

There is another efficient technique for absorbing Carbon dioxide without much loss of water through evaporation. Many desert grasses absorb Carbon dioxide at night and store it in the form of an organic acid. But unlike the *Crassulaceae* family, they do not stop there. The desert grasses take the absorbed Carbon dioxide to specialized cells located in inner parts of the leaves and use it whenever the need arises.

Sometimes the leaves are amazingly adapted to harvest even the most minimal source of water. The *Welwitschia* plant in Namib Desert bears two permanent leaves. These leaves continue to grow throughout the life of the plant. These eventually grow 2-4 m long and split into several strap-shaped sections. The plant is thought to absorb water through peculiar structures on its leaves, harvesting moisture from the dew that comes into the desert every night. The *Tillandsia latifolia* found in the Atacama Desert does not have any kind of root. Its stiff, spiny leaves are arranged in a star-like fashion and it forms a ball-like structure. Water and nutrients are absorbed through the leaves.

A type of stem-less, succulent, perennial plant called living stones (Lithops or stone plants) shows a wonderful adaptation of the leaves. It occurs in the semi-desert regions of Namibia and South Africa and remains almost entirely embedded in the soil, only showing their top surface. This way much of the plant body remains shielded from the Sun. Each

plant consists of a pair of extremely thick leaves fused together. The leaves have adapted to the dry conditions of the plant's habitat by turning into thick, juicy water-storage facilities.

Root Adaptations

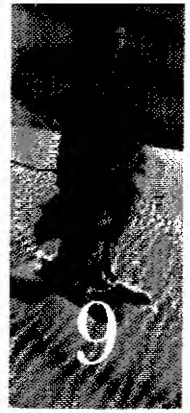
Woody desert plants can either have long root systems to reach deep water sources or spreading shallow roots to take up moisture from dew or occasional rains. Desert plants like melons and squashes have long tap roots that penetrate to the

Creosote bush

water table. The mesquite tree has roots that can extend over 30 metres into the ground. Some cacti have shallow fibrous roots that are mostly confined to the upper few centimetres of soil. Such shallow roots help the cacti collect water from dew formation and occasional showers. The Creosote has an extensive double root system — both radial and deep — to tap water from both surface and ground water.

A problem that desert plants living in or near sand dunes face is the constant changing and movement of the dunes. Moving sand dunes can uproot plants. Therefore, desert plants need to adapt to dune areas. So, grasses and shrubs living in dune areas have developed long, tough roots to hold onto sand dunes. After more plants move into the area, they anchor the dune down with their roots and not even wind can move them.

For much of the year, the desert lies stark and dormant. But even a short spell of rainfall makes it come alive. There is a riot of wildflowers in an entire spectrum of colours. Desert plants are greatly appreciated for their tenacity in the face of adverse conditions and for the wide variety of adaptations that help them conserve water. Desert plants are being screened for various biological activities, such as anti-malarial, anti-bacterial, anti-viral, toxicity against cancer cells under experimental conditions and plants for remediation of polluted soil and water as well as their ability to withstand heat stress and salt-stress.



Desert Animals

"The vast, dry expanse of a desert may look uninhabited but all kinds of plants and animals survive in these sandy regions-including insects, reptiles, mammals, and fish".

Children's Illustrated Encylopedia, Dorling Kindersley Limited, London, 1998

It is not easy to thrive in deserts. Food and water are in short supply and there are extreme temperature variations—one may bake during the day and freeze at night. In spite of such harsh conditions, many animal species thrive in deserts. This is possible because desert animals have developed protective mechanisms to allow them to survive in the desert environment. In day-time deserts may appear almost lifeless but variety of animals come out of their hideouts and make the deserts a lively places as soon as the Sun sets and the temperature drops to a bearable level. Such animals (especially mammals and reptiles) are called crepuscular, that is, they are active only at dusk and again at dawn.

Most desert animals and insects are small, so they can remain in cool underground burrows or hide under vegetation during the day and feed at night when it is cooler. The animals that go underground to escape the heat include insects such as grasshoppers and ants; mammals such as kangaroo rats, rabbits, badgers, kit foxes, coyotes and skunks; reptiles such as lizards (example Gila monster) and snakes (example rattlesnakes); and birds such as burrowing owls.

Fox in desert

Desert Insects

For many of us desert animals mean only the camel—immortalized as the ship of the desert, snakes and lizards. We almost never think about insects when enumerating the names of animals that have made the deserts their home. However, insects are well represented. Compared to other animals they are better equipped to cope with the desert environment. As their body design is very suitable for desert life. The hard outer covering of an insect (the cuticle) is made of chitin—a tough waterproof substance. And some even have an extra waxy layer

on top of the cuticle. This traps the moisture inside the body and little, if any, water is lost by evaporation. Desert insects can be broadly divided into two groups:

i. Insects which are efficient fliers
ii. Insects which are poor fliers or have no ability to fly at all.

Insects with good flying ability can escape from the prolonged drought periods by migrating elsewhere and return after rainfall. Swarms of desert locusts (*Schistocerca gregaria*) migrate long distances over Northern Africa and the Middle East. Some insects tap plant fluids such as nectar or sap from stems, while others extract water from the plant parts they eat, such as leaves and fruit. The abundance of insect life permits insectivorous birds, bats and lizards to thrive in the desert.

Desert Locusts

Beetles are common in deserts and some show amazing adaptations. For example, the surface of the Namib beetle's back is covered with bumps. The peak of each bump is smooth and attracts water. The slopes of each bump, and the troughs in between, are covered with wax, which repels water. As the morning fog rolls in, the water sticks to the peaks of bumps, eventually forming droplets. When the droplets become large and heavy, they roll down from the top of the peaks and are channeled to a spot on the beetle's back that leads straight to its mouth. So efficient is the system that scientists think it could


Melophorus

be a good model for designing inexpensive tent coverings and roof tiles that could collect water for drinking and agriculture in arid regions.

There are at least three genera of ants found in the deserts that carry out their daily activities despite the high temperatures. These include *Cataglyphis* in North Africa, *Ocymyrmex* of South Africa, and *Melophorus* of Australia. *Cataglyphis* lives in the Sahara Desert and forages at a body temperature well above 50°C and on surfaces heated to 70°C – temperatures high enough to roast other insects.

Desert Arachnids

Deserts support a diverse group of invertebrates called arachnids. Arachnids include predatory species such as spiders and scorpions that get their water source from the bodily juices of the animals they eat.


Scorpion

Desert Fish

Fish need standing water for their survival. So it is surprising that fish survive in deserts. Fish are found in Death Valley, one of the hottest deserts on Earth. Several species of the desert

pupfish (*Caprinodon spp.*) live in small, fresh or brackish water springs. Desert fishes can tolerate wide fluctuations of temperature, high mineral load in the water mineralization and low oxygen content.


Pupfish

Desert Amphibians

Desert toads remain dormant deep in the ground until the summer rains fill ponds. They then emerge, breed, lay eggs and replenish their body reserves of food and water for another long period. For example, the California red-spotted toad (*Bufo punctatus*) spends up to 10 months a year buried underground, living off of the water stored in its overly large bladder. The dormancy of desert amphibians during dry periods is called aestivation. Desert amphibians like spadefoot toads (*Scaphiopus spp.*) can go down almost one metre in the moist soil and remain there for up to 9 months before coming back to surface. While aestivating their metabolic rate drops dramatically. Their skin layers become harder and leathery to reduce water loss. When it rains, they mature rapidly, mate, and lay eggs. Desert amphibians that pass through larval stages have accelerated life cycles so that they have a fair chance of reaching maturity before the waters evaporate. Amphibians


Red spotted toad

must complete their life cycles before the water evaporates shortly after the rain.

This is important because amphibian eggs are laid in the water and most pass through an aquatic larval stage. The problem most desert amphibians face is that they live at the very physiological edge of survival. Many populations are isolated and depend on a single water source, rendering them incredibly vulnerable to human disturbance or changing climate.

Desert Reptiles

There is a variety of reptiles in deserts including lizards, snakes and tortoises. Reptiles have thick skins that protect against

Lizard

water loss. And so, they are in a better position than the moist-skinned amphibians. Reptiles utilize heat sources outside their bodies to maintain a preferred body temperature range and therefore are called "cold-blooded animals". The high average

temperatures and intense sunshine in deserts are ideal for such animals. It is easier for them to thermo-regulate within the preferred temperature range for longer periods of the day and year in warm deserts than in cooler climates.

When a cool and sluggish lizard or snake crawls out of its refuge in the morning it immediately orients its body to maximize absorption of radiation from the Sun. Once it reaches its optimum body temperature, it uses a variety of behavioral techniques to stay within its preferred range. One technique is to move back and forth between shade and Sun, continually fine tuning its body heat. Another way is to utilize conduction by pressing its body against a cool substrate such as the inside surface of a rock or crevice or by pushing aside soft sand maximizing contact with its belly.

Most snakes are nocturnal, preferring to come out at night and thus avoiding heat extremes. Reptiles excrete metabolic wastes in the form of uric acid, an insoluble white compound, wasting very little water in the process. Desert reptiles such as the horned lizard (*Phrynosoma*) can control their metabolic heat production by varying their rate of heartbeat and the rate of body metabolism. Some snakes have developed a sideways shuffle that allows them to move across soft sand.

Desert Birds

A variety of birds are found in deserts. Birds are highly visible in the desert because of sparse foliage cover. Under normal circumstances birds and mammals can (unlike amphibians and reptiles) maintain a constant body temperature irrespective of ambient conditions. They are called homoeotherms.

Many birds are active at dawn and dusk, retiring to a cool, shady spot for the remainder of the day. This way they can beat the heat for the greater part of the day. Desert birds include

cardinals, road runners, kingbirds, tanagers, quails, owls, nighthawks, swifts, crows, woodpeckers, grouse, wrens, and thrashers. Some birds are year long residents. Others are migratory birds or transients found in the desert during certain seasons. Using the desert only as a breeding ground allows birds to avoid seasons of extreme heat, cold and drought. An avoidance strategy is to seek out a cool microclimate. A cactus wren may simply rest quietly in the shade while a prairie falcon will nest on a ledge of a cool north-facing cliff and avoid the hot south face.

The great Indian bustard

Many desert animals are paler than their relatives elsewhere. Pale colours may be seen in feathers (or fur, scales or skin in other animals). Pale colours not only ensure that the animal takes in less heat from the environment, but help to make it less conspicuous to predators in the bright surroundings. The Turkey and Black Vultures, are exceptions, being dark in colour and thus absorb considerable heat in the desert. But they excrete urine on their legs, cooling them by evaporation, and circulate the cooled blood back through the body. This behavior, called urohydrosis, is also exhibited by the storks— birds of the African deserts. Both vultures and storks escape the hot midday temperatures of the desert by soaring high on thermals of cooler air. Also, by dilating the blood vessels going to its bare scaly legs, a bird can dump excess body heat to the environment. When feeling hot, birds flap the loose skin under

their throats. This is called gular fluttering and achieves the same result as panting, the way dogs lose heat.

Desert Mammals

Usually large predatory mammals do not live on deserts. Lions and jackals found in Namib and Kalahari deserts are exceptions. Among other mammals that have made deserts their home are: elephants, giraffes, camels, donkeys, goats, Arabian oryx, gazelles, kangaroo rats, jerboas, gerbils, fennec fox, kit fox, mulgara, and meerkats.

All mammals living in deserts have adapted themselves to the harsh conditions of desert environment. Smaller mammals escape the heat simply by avoiding it. They mostly live underground in burrows during the day and come out at night when it is cooler. Those species that do come out of their burrows in the day, do so only for a brief period.

Larger animals cannot hide underground. So most large mammals have developed a thick coating of hair on their upper surface. The thick hair insulates the tissues beneath and the animal remains relatively cool. A light-coloured coat helps to reflect some of the heat.

Some species of jerboa and gerbil move in quick leaps and so they can reduce contact with the burning ground. They can do so because they have large hind legs. These animals have short and strong front legs, which are suitable for digging in the ground. Many larger desert animals have broad hooves or feet to allow them to move over soft sand. Some desert rodents (for example the North American kangaroo rat and the African gerbil) have large ears with little fur. The naked skin surfaces help to dissipate heat into the surroundings. These animals can also manage with very little water. The

enormous ears of jackrabbits, with their many blood vessels, also release heat when the animal is resting in a cool, shady location. Their relatives in cooler regions have much shorter ears. Some desert mammals also aestivate to escape the periods where food or water is scarce.

The oryx and addax found in the deserts of Africa and the Middle East can make do with water derived from the cellulose of plants, even very dry ones. They normally source water from leaves covered in dew, or by eating the water-filled leaves of succulents. Some small animals like Mongolian rodents and jerboas never drink. Like the oryx and addax they can collect water by hydrolysis from the cellulose of plants they eat.

The predators like fennec cat and other desert cats meet their requirement of water mostly from bodily fluids of their prey.

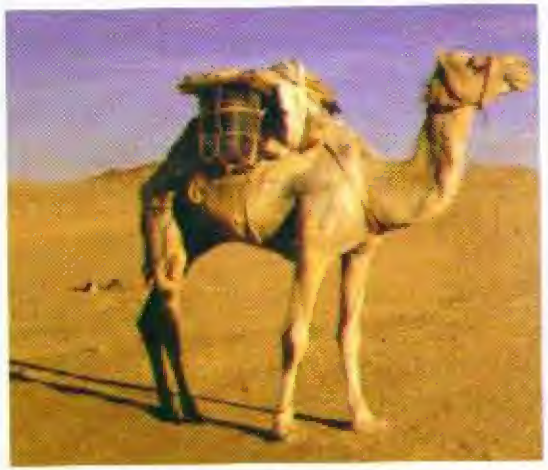
Kangaroo Rat

Kangaroo Rats, live in underground dens which they seal off to block out midday heat and to recycle the moisture from

their own breathing. Much of the moisture that would be exhaled in breathing is recaptured in the nasal cavities by specialized organs. These rodents have specialized kidneys with extra microscopic tubules to extract most of the water from their urine and return it to the blood stream. Kangaroo Rats, and some other desert rodents, actually manufacture their water metabolically from the digestion of dry seeds. These highly specialized desert mammals will not drink water even when it is given to them in captivity!

Adaptations of the Camel

The desert mammal that deserves special mention is the camel. There are two types of camels—the dromedary camel or the



Camel the ship of desert

one-humped Arabian camel (*Camelus dromedaries*) and the two-humped Bactrian camel (*Camelus bactrianus*). Over 90 percent of the world's camels are Dromedaries.

Like all other desert animals, the camel also employs physiological adaptations to adjust to the desert. It is able to

travel great distance without eating and drinking. Camels can tolerate greater that 30 per cent water loss, a condition which is lethal for most other mammals, most of which will die if water loss exceeds 15 per cent. A dehydrated camel can drink more than 50 litres of water at one time and often there may be a stampede at the water hole if many dehydrated camels gather there. If allowed unlimited access to water, a camel likes to drink just like any other animal. If water is at hand, it will drink copiously every second day or so.

Camels are well known for their humps. They do not, however, store water in them as is commonly believed. Their humps are a reservoir of fatty tissue, which gives water as bye-product of metabolism.

Camels are physiologically adapted to tolerate a rise in body temperature. The camel's body temperature can change greatly in a single day. The camel's ability to fluctuate its body temperature throughout the day from 34 degrees Celsius to 41.7 degrees Celsius allows it to conserve water by not sweating as the external temperature rises.

With its tough lips, a camel can tear off and eat thorny plants. The extremely mobile lips of the camel and the tough inner skin of the mouth enable the camels to graze thorn bushes. One of the most advantageous attributes of the camel is its ability to utilize plants that grow well under arid conditions and are unacceptable to other grazing animals. Examples of such plants are the camel thorn, acacia and salt bushes.

Camel eyes are protected from sand and dust by a double row of eyelashes. The eyelashes arch over the eyes like screens and that keep out both sand and the sun's brightness. Apart from the heavy, protective eyelashes, a camel also has hairy ear openings and hairy kneepads. The camel's nose is pretty

amazing. It traps the moisture in the camel's breath and absorbs it in nasal membranes. Tiny blood vessels in those membranes take the moisture back into the camel's blood. There are also special muscles in the nose that close the nasal opening so that sand cannot get in, but air can.

A camel has slimly built legs that help it move easily over the desert. Its feet have tough leathery skin between the toes so they will not sink into the sand. In a sandstorm, the camel kneels down on its thick kneepads, presses its ears flat, shut its eyes and closes its nostrils to avoid breathing in too much of the sand and dust raised by the storm.

When we examine the trade routes, once associated with camel caravans, the realization of both the camel's value as a beast of burden and its incredible endurance and vitality becomes evident. And much of that ability to endure comes from morphological and physiological adaptations that have made it so much at home in the deserts.

Peoples of the Desert

"Throughout history, deserts have been regarded as empty, inhospitable places. To all but an enterprising few, they have been barriers to movement and trade. People have had to develop survival strategies based on the conservation of very scarce resources. In recent decades however, the extraction of hydrocarbons and other minerals has brought about the transformation of some desert societies".

Deserts: The Encroaching Wilderness

The great diversity of human societies found in deserts is truly amazing and people have colonised deserts for centuries; this, despite the fact that deserts are among the most hostile places on the Earth. However, it must be admitted that human settlements are usually on the desert margins while the deep regions of the deserts are inhabited by nomads. Because human beings can change very little physically to adapt to desert conditions, they must change their behaviour to survive in the desert. And across time people have done so although it has

been estimated that very little of the world's population lives in deserts.

Some of the earliest civilizations existed in places, which are deserts today. Our earliest ancestors lived, as evident from their remains and artefacts, in the desert regions of East Africa. People living in deserts especially in the Nile, the Tigris-Euphrates and Indus river valleys created the first agricultural economies. These economies were characterized by the development of settled, irrigated farming. Inhabiting the deserts was a slow process. The first obstacle in this process was finding enough water for drinking and cultivation. It is quite possible that communities or tribes of people, being driven away by invaders, took refuge in deserts, as these places are isolated and inaccessible.

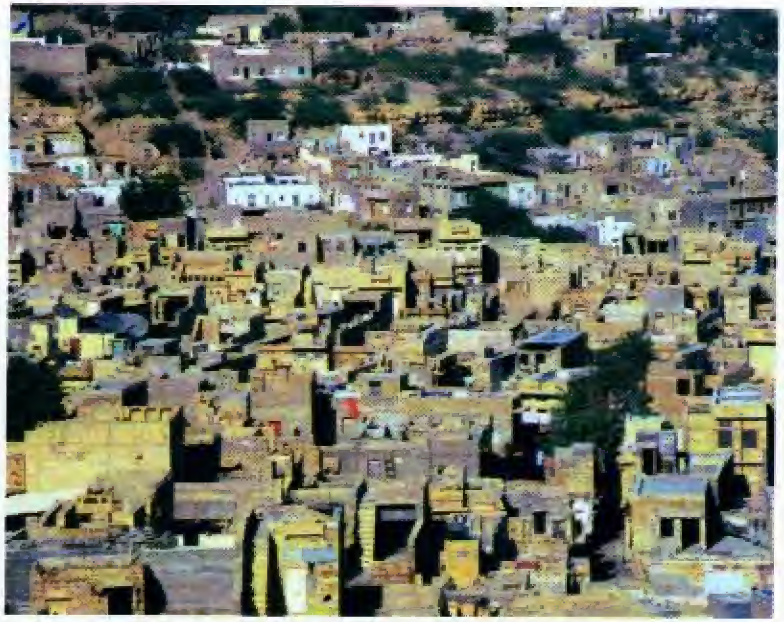
Problems of Living in Deserts

It has always been a great challenge to live in deserts. Air and water are essential to sustain life, but the three basic requirements of food, clothing and shelter cannot be bypassed either. In deserts, air is abundant, but water, food and material for making clothes are in short supply.

There is not enough water and consequently there is not enough scope for growing crops. The situation becomes more acute when there are prolonged periods of droughts. Constructing shelter has also remained a challenging task for people living in deserts as construction materials are in short supply. The problems do not end here. People living in deserts must escape the intense heat (in hot deserts) and the extreme cold (in cold deserts). Even in hot deserts the nights are very cold. There are other hazards like dust storms, migrating dunes and blowing sand.

Houses in Desert

The materials for constructing houses or shelters are scarce in deserts. The earliest people, who colonised deserts lived in naturally-made caves. Gradually people started building shelters by using rocks and sun-baked mud bricks. All desert homes need to be well insulated from extreme heat and cold. Village houses in the desert are still made of mud bricks dried in the Sun. Because there is so little rain, the bricks do not need to be waterproof.



Houses in Jaisalmer

Animal skins, wood and cloth were also used for making shelters. Most settlers clustered around water holes or oases. They needed to make permanent homes. Even nomads needed temporary shelters. They built tents by using cloth and hides over wooden frames. The dwellers of Mongolian deserts live

in yurts—tent-like structures made from felt sourced from sheep's wool. The felt is stretched over a wood frame, and a hole at the top of the yurt allows smoke from cooking fires to escape. Traditionally, the Hopi and Zuni tribes who are native Americans of the south-western desert built homes, called pueblos, from mud, wood, and stone. The thick walls and small windows keep the interior cool. The Navajos made hogans, houses of logs and mud. Because they were always on the move in search of game and plant foods, the San tribe (Bushmen of South Africa) did not build permanent settlements. Shelters that they built were temporary structures built from a framework of branches covered with grass and scrub. The base structure of the Xhosa beehive huts was made by bending thin pliant poles that were stuck into the ground, to form a round structure. This was then covered with a mixture of clay and cattle dung, both inside and out.

With the inroad of modern technologies in deserts, the nature of desert dwellings has changed considerably.

Desert Clothing

The clothes used by desert people are determined by the climate, local culture and religion. Most traditional desert peoples wear layers of loose-fitting garments that protect the body from the heat. An unclothed person absorbs twice as much heat as a person in lightweight clothes. Also, loose clothing absorbs sweat and, as the air moves through, it produces a cooling effect. As a result, the person sweats less, and this conserves water.

A distinctive feature of the male members of the nomadic groups living in deserts of Arabia and northern Africa is their headgear that shields the face from the Sun and blowing sand. The Fulani, who live on the edge of the Sahara in West Africa, wear decorated hats made from plant fibres and leather.

Women also wear distinctive headdresses. The Xhosa women wear magnificent turbans of wrapped cloth decorated with beaded rings, and pins.

People of Jaisalmer, Rajasthan, India

Access to Food

Traditionally the availability of food, to both humans and animals in deserts, has always been uncertain. Livestock rearing and limited agriculture are possible in some deserts. Not all plants can be grown in deserts. Grain cultivation, in particular, is difficult in deserts. Local farmers like to cultivate drought tolerant edible perennial plants, which they can use for food and those that stabilise the sand dunes at the same time. This limits the accessibility of fruits and vegetables to those that can be grown locally or those that can be procured from nearby areas. It is easier to hunt or trap animals or sacrifice domesticated ones for food.

Native dwellers of deserts knew how to find edible items even under the harshest conditions. For example, the seemingly inhospitable Sonoran Desert has provided sustenance to indigenous peoples for centuries. Although, to all appearances it is a land bereft of useful plants, but one-fifth of the desert's flora are edible. There are almost 540 edible plants used by people of more than fifty traditional cultures of the Sonoran Desert and peripheral areas.

The fruit of Opuntia

Desert people traditionally ate wide variety of uncultivated plant foods in the form of roots, starchy tubers, seeds, fruits and nuts. The plant foods were generally high in fibre and contained carbohydrates, which was slowly digested and absorbed. Traditional methods of food preparation (usually baked whole or eaten raw) ensured maximum retention of nutrients.

A few examples of edible desert plants include the wild desert gourd, a member of the watermelon family, that bears perfectly round gourds. This plant grows abundantly in the Sahara and some of in the hottest localities of the world. Locals know that the seeds inside the ripe gourd are edible after they are completely separated from the very bitter pulp. The seeds are rich in oil and they are eaten roasted or boiled. The flowers are edible. The succulent stem tips can be chewed to obtain water. Native desert dwellers knew that the fruit of prickly pears (a type of cactus), called "tuna", is edible, although it has to be peeled carefully to remove the small spines on the outer skin before consumption. They used it to make jelly and a refreshing drink. The seeds can be used in soups or ground into flour. Ocotillo, is a woody shrub that bears reddish-orange blossoms that are relished raw. Locals also make a tea from the plant's flowers and seeds. The Agave plant is high in moisture and sugar. The base of the plant can be roasted. The stalk can be cut into segments and the centre eaten raw or cooked. The buds and flowers are also edible, as are the fruits.

Date palms fringing oases are almost picture postcard material. It is thought that the date palm originated somewhere in the desert oases of northern Africa, and perhaps also southwest Asia. Dates can be dried, ground up and mixed with grain to form a nutritious stockfeed. Dried dates are fed to camels, horses and dogs in the Sahara. Young date leaves are cooked and eaten as a vegetable, as is the terminal bud or heart, though its removal kills the palm. The finely ground seeds are mixed with flour to make bread in times of scarcity. The flowers of the date palm are also edible. The flower buds are used in salad or ground with dried fish to make a condiment for bread.

The diets of desert people are usually rich in animal fats and proteins. The nutritional status of people living in desert

margins is certainly better than those living deep in the deserts. But even desert margin diets are liable to show variations because of the great variation of rainfall from year to year.

The food habits of desert folk have also greatly changed with the advent of modern technologies in desert life.

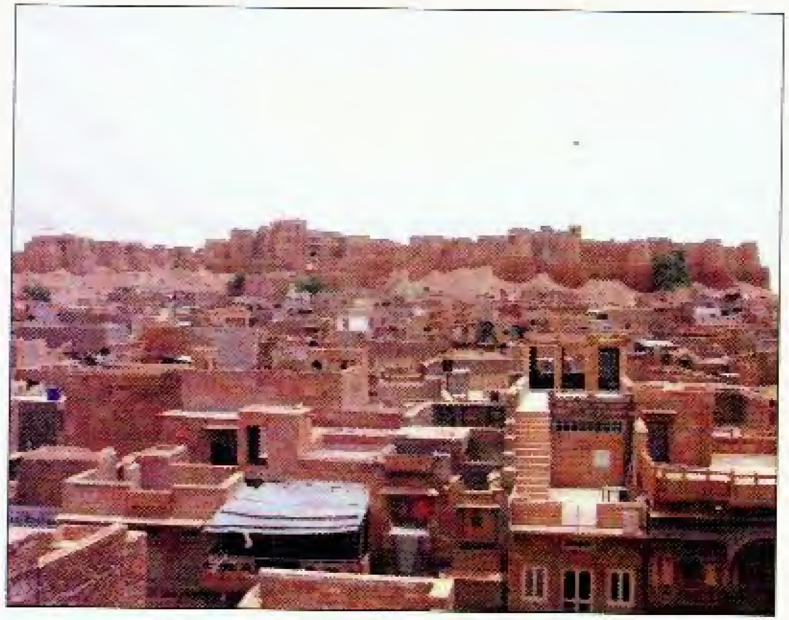
Contemporary Desert Life

Like in other regions of the world, the population in deserts is also increasing. Human populations of the world's deserts have been growing rapidly since the beginning of the 20th century. Today nearly one-sixth of world's human population live in deserts. The increase in population in deserts is not geographically uniform. There are many reasons for this population increase. Traditionally desert people see children as a means of economic strength and source of security in their old age. Technological breakthroughs have made it possible to exploit the desert resources including groundwater and oil on a much larger scale. And people have migrated as newer areas have become comparatively more hospitable. There is considerable migration of people to desert areas particularly to desert margins.

The increase in population living in deserts has serious impacts on the environments of the deserts. The life-style of people living in desert regions has undergone a sea change and this has had a negative effect on the desert environment. Desert natural resources are being severely depleted and are almost insufficient in most parts of the deserts to maintain the growing population. The non-renewable resources of the deserts are being depleted by overuse. The renewable resources are being degraded because of unplanned and over use.

Many desert countries have created huge wealth from oil resources and with this enormous wealth these countries have

changed the desert landscape by greening major urban centres and highways. Many new major urban centres have come up in deserts.



Contemporary desert city in India

Today the traditional livelihoods of many desert people are under threat. Social changes have led to the abolition of many traditional values practised by desert people, which imposed restriction on the overuse or exploitation of the natural resources. But before any hasty steps are taken, it must be remembered that the different deserts of the world are unique in terms of origin, evolutionary history and climatic patterns. They need tailored management and policies to protect them.

11

Cold Deserts

"Perhaps the strangest of all desert biomes is the cold desert, as our perception of the desert is usually associated with the heat of the Sun".

www.worldbiomes.com/biomes_desert.htm

The term "Cold Desert" seems to be counter-intuitive, almost illogical—for public perception has almost wedded the word hot with the word "desert". But cold deserts are a harsh yet beautiful reality.

Cold deserts are characterised by cold winters with snowfall. This kind of environment is found on the peaks of high mountains and near the Poles. Cold deserts occur in the Antarctica, Greenland and the Nearctic regions. These areas experience high overall rainfall throughout winter and occasional rainfall in summer. In some cold deserts where the weather is very cold and snow never melts, the annual rainfall (which is actually snowfall) cannot sustain life. In cold deserts mean average temperatures in winter ranges from

-2 to 4 degrees Celsius and in summer from 21 to 26 degrees Celsius.

Most of the cold deserts are either rocky or covered with snow. Nothing grows in deserts covered by perennial and so, there is nothing to eat in the snow-covered land. All water is locked up as ice and for all practical purposes, cold deserts

Cold desert

and hot deserts share a paucity of water. In fact the paucity of water in cold deserts is often worse than that in hot deserts. The driest deserts on the Earth are the dry, cold deserts in Antarctica.

Traces of Life

The low temperature discourages any growth (be it of plants or animals) since it slows down chemical reactions in plants, micro-organisms and animals, particularly the cold-blooded ones. Plants in cold deserts are few and scattered. In some cold deserts there is not enough sunlight necessary for the growth

of plants and in these cold deserts, which are situated at high altitudes the excessive ultraviolet light also harms the plants.

Paradoxically enough, the most visible life-forms in cold deserts are the large, warm-blooded animals, though their number is less. By and large, most cold-blooded animals avoid cold deserts. This restricts the biological diversity of the area.

Snow leoperd

Animals that make their home in the cold deserts must be able to adapt to the extremely cold winters. One way to do so is to burrow underground. The snow blankets the land and acts as a good insulator, trapping heat that comes from the ground. Most of the animals in the cold desert are burrowers, that is, they live under the ground.

Insulation is the key to survival under very cold conditions. Musk ox, for example, have two layers of protective fur. The outer layer is made of long hairs that protect the animals from wind and water. The woolly inner layer of fur

traps air next to the body. Body heat warms the air, keeping the musk ox cozy warm even at -40 degrees Celsius! Even birds have responded similarly to the cold, developing thick layers of feathers.

Ladakh: India's Cold Desert

Ladakh is India's most prominent cold desert. It is also called the land of rock or the land of many passes. Ladakh covers an area of approximately 117,000 square kilometres. Ladakh is

Leh Ladakh

among the highest of the world's inhabited plateaus; located at an altitudes ranging from 2750 metres to 7672 metres. Four major mountain ranges crosses through or touch Ladakh—the Great Himalayan, Zanskar, Ladakh and the Karakoram. This high altitude, cold desert is sheltered from the rain-bearing clouds of the Indian monsoon by the barrier of the Great Himalayas. Ladakh was not always a cold desert. It was once

covered by an extensive lake system, the remnants of which are visible even today. Ladakh has dry atmosphere, rocky and uneven terrain and very low temperature. Rainfall is very rare here.

Temperatures in Ladakh are the most extreme here. In winter temperature can reach as low as -45^{0}C. In spite of such harsh conditions, Ladakh is not lifeless; there are some animals and plants that have adapted to survive in such harsh conditions.

Vegetation is extremely sparse in Ladakh except wherever some water is available. Several wild herbs and shrubs manage to survive alongside the banks of these tiny streams. Some vegetation is also found on irrigated areas of high slopes. Many birds migrate to Ladakh from the warmer parts of India in summer. For such an arid area, Ladakh has a great diversity of birds — a total of 225 species have been recorded, though many are just migrants. Species of finches, robins, redstarts and Hoopoe are common in summer. The Brown-headed Gull, Brahminy duck (Ruddy Sheldrake), Bar-headed Goose, Black-necked Crane, Raven, Red-billed Chough, Tibetan Snowcock, Chukar, Lammergeier and the Golden Eagle are seen here.

Among the mammals found in Ladakh are the endangered Ibex, yak (a wild ox), Nyan- the largest sheep found in the world (Great Tibetan sheep), Bharal (blue sheep), Urial—the smallest

Urial—the smallest sheep

sheep found in the world, Shapu goat, brown bear, marmots, hares, voles Chiru, or Tibetan antelope, Kyang, or Tibetan Wild Ass, Snow Leopards, Lynx, Pallas's cat, Tibetan Wolf are found here. The Tibetan Sand Fox has recently been discovered in

Yak

this region.

The people of Ladakh lead a very traditional life. They herd sheep and yak and grow barley near the river beds in summer.

How to Stop Desertification?

"Desertification is a slow and less perceptible process that gradually leads to decline of production potentials of land and affects the socio-economic fabric of the people who make a living from those lands. It is usually takes place when the natural geomorphic processes are accelerated by human actions, or when extreme natural events like climatic conditions (including droughts) strike an area."

Amal Kar in Coping with Natural Hazards: Indian Context, K S Valdiya (Editor), 2004.

The transformation of arable or habitable land to desert is called desertification. It is true that when deserts move they move with immense power. But desertification does not mean that the existing deserts expand by shifting walls of sand. Of course, this does happen but it is a very rare phenomenon for a desert to expand in this manner.

The term "desertification" was first used by the French scientist A. Aubreville in 1949, in his book *"Climate, Forets, et Desertification de l'Afrique Tropicale"*. Some say the term was first used by L. Lavauden in 1927, to describe forest decline in the Sahara. Aubreville conceptualized the process of desertification as the changing of productive land into a desert as the result of degradation of land caused by human activities in humid and sub-humid tropics in Africa.

Analysing satellite images taken over a sustained period of time it has been found that deserts do expand and contract

Erosion from overgrazing

but they do so within well-defined ranges. They expand when the climate is dry and they shrink when the climate becomes more moist. Desertification refers to the gradual degradation of productive arid or semi-arid land into biologically unproductive land (e.g., a change of grassland to desert). Desertification is best regarded as a process of continuous ecosystem degradation, including damage to plants and

animals, as well as to resources such as water and soil. Desertification is usually discussed in the context of dry regions and ecosystems, but it can also affect prairies, savannas, rain forest, and mountainous habitats. The effects of desertification can range from minor to severe.

Desertification is a natural disaster albeit a slow-onset disaster. An area does not become a desert or acquire desert-like conditions within short span of time. It takes a long time. However, it can be aided or augmented by human activities. The process of desertification manifests as a part of good and bad weather cycles. It does not become catastrophic immediately. Desertification is caused by the interaction between a harsh, unpredictable and vulnerable dry land environment and the way humans exploit the land for making a living.

The signs of its approach can be recognized much before it acquires a catastrophic proportion. The causes responsible for land destruction are indiscriminate felling of trees, over-grazing, forest fire, and cultivation, which expose the soil to water and wind erosion. Aubreville found that desertification in tropical Africa was caused by human activities and there had been no significant climatic change in the recent past. He perceived desertification as localized activity and it could begin anywhere. Thus people who live in areas vulnerable to desertification must be prepared to live and work in harmony even under the constant threat of desertification. They must realize that desertification cannot be escaped by simply abandoning the area. Often it has been found that the desert follows the people who moved out the desert.

The phenomenon of desertification is not simply the case of desert expanding. Desertification, in simple terms, means degradation of land in arid, semi-arid and dry sub-humid areas.

The degradation may results from various factors including climatic variations and human activities. Desertification in modern time often arises from the demands of increased populations that settle on the land in order to grow crops and graze animals.

There has been major controversy over the very definition of the term, as well as about the factors that cause it. Attempts to define or map areas that are or have turned into desert are

The phenomenon of desertification is much more than the case of desert expanding

often subject to sharp criticism. However, there is no disagreement over the fact desertification leads to biodiversity loss, and that it can make the affected land permanently unsuitable for farming.

The UN Conference on Desertification at Nairobi in 1977 described desertification in the following way: "...the diminution or destruction of the biological potential of the land,

(which) can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems, and has diminished or destroyed the biological potential i.e., plant and animal production, for multiple use purposes at a time when increased productivity is needed to support growing populations in quest of development. Important factors in contemporary society—the struggle for development and the effort to increase food production, and to adapt and apply modern technologies, set against a background of population growth and demographic changes – interlock in a network of cause and effect. Progress in development, planned populations growth and improvements in all types of biological production and relevant technologies must therefore be integrated. The deterioration of productive ecosystems is an obvious and serious threat to human progress. In general, the quest for ever greater productivity has intensified exploitation and has carried disturbance by man into less productive and more fragile lands. Overexploitation gives rise to degradation of vegetation, soil and water, the three elements which serve as the natural foundation for human existence. In exceptionally fragile ecosystems, such as those on the desert margins, the loss of biological productivity through the degradation of plant, animal, soil and water resources can easily become irreversible, and permanently reduce their capacity to support human life. Desertification is a self-accelerating process, feeding on itself and as it advances, rehabilitation costs rise exponentially. Action to combat desertification is required urgently before the costs of rehabilitation rise beyond practical possibility or before the opportunity to act is lost forever."

We must remember that the problems of desertification do not result from the fact that people do not know how it is caused or how it can be prevented. Desertification often results because of people's inability to apply what is already known. Farmers, particularly in poorer countries, who are often

instrumental in ruining the soil, know what needs to be done for preventing desertification. But they are unable to implement the steps because of excruciating poverty. Traditionally, humans have evolved ways to lead a sustainable life in desert-like areas. However, with the increase in population the demand on land grew and the good practices developed over the years were abandoned.

It is fortuitous that the true implication of land degradation has been recognized now though land degradation as a process is not a recent phenomenon. There is strong historical evidence to indicate that the three major epicentres of massive land degradation were the Mediterranean Sea, the Mesopotamian Valley, and the loessial plateau of China. There were other places where land degradation occurred but their effects were not very extensive.

Some people believe that desertification is purely a natural process. According to this kind of thinking we can safely blame nature for desertification. Some others think that human activities are solely responsible desertification. It would be reasonable t say that neither of the two viewpoints is fully correct. It is a combination of natural process and human activity acting together that creates the problem of desertification.

Among the natural forces responsible for desertification are:

i. Erosion of soil by wind and water.
ii. Long-term changes in rainfall patterns, and other changes in climatic conditions.

Determining the causes behind desertification is not an easy task. Though certain activities have been identified as having a bearing upon desertification. These are:

i deforestation,
ii. vegetation loss by overgrazing,
iii. the depletion of groundwater,
iv. surface runoff of rainwater,
v. the influence of invasive non-native species,
vi. physical compaction of the soil by livestock and vehicles, and
vii. damage by strip-mining.

Deforestation and over-grazing, the principal causes of desertification

Deforestation and over-grazing have been recognised as the principal causes of desertification. As livestock numbers have increased, vegetation has been stripped from rangelands, and the pounding hooves of hungry animals have turned the exposed soil to dust. The percentage of the fine material in the soil also increases. This encourages land erosion by wind and water. Plants help to bind the soil. Grazing and the collection of firewood reduce or eliminate plants and thus add to the process of land erosion. The vicious cycle rages on.

Determining the exact contribution of climate variation to the problem of desertification is not an easy task. Climate change alters the frequency and severity of drought in various parts of the world. However, it is not necessarily true that drought and desiccation will, by themselves, induce, or even contribute desertification in dryland regions. The end result is dependent on the nature of resource management in these areas.

The relative contribution of human activity and climate variation to dryland degradation tends to vary from region to region and from time to time. The most challenging task is to identify the relative role of these factors in order to identify the most appropriate response in any particular situation. The assessment is complicated by the fact that desertification itself may cause climate change.

Global warming brought about by increasing greenhouse gas levels in the atmosphere is expected to increase the variability of weather conditions. The warming of desertified areas may well have been great enough to produce a measurable effect on global-mean temperature over recent decades. But the influence appears limited compared to that of factors such as enhancement of the greenhouse effect. It has been estimated that the effect of desertification on global-mean temperature is unlikely to have exceeded +0.05° C a century.

In some regions of the world, deserts are separated sharply from the surroundings, either by mountains or by other contrasting landforms having structural differences in the regional geology, which are fundamentally different from the deserts. In some cases, desert fringes form a gradual transition from a dry to a more humid environment. In such cases it becomes difficult to define the desert border. Such transition zones display very fragile, delicately balanced ecosystems.

Desert fringes often are a mosaic of microclimates. The marginal areas are very susceptible to human activities. Often human activities may stress the ecosystems of such marginal areas beyond their tolerance limits. The end result of all this is further degradation of the land.

Some arid and semi-arid lands support crops. However, the increase of population or decrease in rainfall often leads to the disappearance of the few existing plants. In the absence of plants, the soil becomes exposed to wind and this causes soil particles to be deposited elsewhere. In the process the top layer becomes eroded. When there are no plants, there are no shadows. When there is no shadow, rates of evaporation increase and salts are drawn up to the surface. This process is called salinisation and it inhibits plant growth. The loss of plants can also cause lower rainfall. This is because the loss of plants causes less moisture to be retained in the area resulting in the change of the climate pattern in the area.

Droughts are considered to be one of the major natural occurrences for desertification. Some people believe that in some climates, droughts are truly natural phenomena. However, it cannot be denied that human activities increase their frequency and sometimes droughts can be created by human activities.

It should be emphasised that droughts alone do not cause desertification. Droughts are common in arid and semi-arid lands. Well-managed lands can recover from drought when the rains return. However, if there is continued land abuse during droughts, then droughts can enhance the process of land degradation. It is a fact that increased population and livestock pressure on marginal lands can accelerate desertification. There are instances when nomads moving to less arid areas disrupt the local ecosystem and such disruptions increase the rate of land

degradation. It is ironical that by the very process of trying to escape the desert, the nomads create more deserts. This is because of their land-use practices. The lesson is obvious. We must learn to live with the desert and value those practices, which do not aggravate the situation if not reverse it.

There is a human aspect of desertification. Desertification results in a decline of the land's productivity. Increased flooding leads to the removal of topsoil and vital soil nutrients needed for food production. Thus the immediate fallouts of desertification particularly in developing countries are:

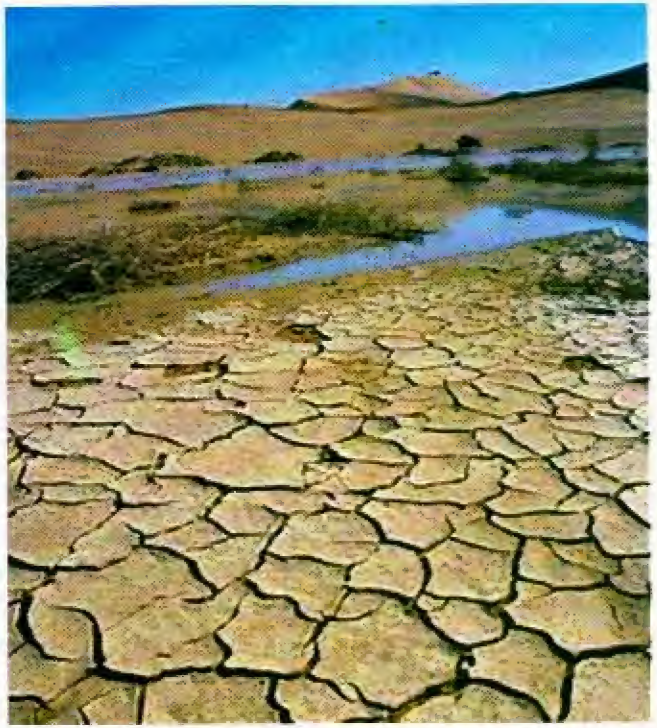
i) Worsening poverty that brings malnutrition and disease in its wake.
ii) Weakening of national economy and consequent deterioration of social services.
iii) The loss of vegetation cover means increased of carbon dioxide in the atmosphere. Since plants help to remove carbon dioxide from the atmosphere.

Among the physical consequences of desertification are:

i) An increased frequency of sand and dust storms.
ii) Increased flooding due to inadequate drainage or poor irrigation practices.
iii) Desertification can also initiate regional shifts in climate, which may enhance climate changes due to greenhouse gas emissions.

If desertification continues unabated then almost the entire population of the Earth's dry lands could be said to face eventual risk. Between 600 to 700 million people depend on these drylands for sustenance. But there is a sort of rough justice at work here. If humans are the victims of desertification they are also partly responsible for causing it. Desertification results

from the interaction between people and a difficult, changing environment. Desertification occurs when humans exploit lands without proper regard for its sensitivities and limitations.



Desertification is a dynamic process

Desertification is a dynamic process. Once started, it can feed on itself. In that sense it is a self-sustaining process and it can become a self-accelerating process as well. So if we fail to take steps to contain the process it may reach a threshold beyond which it is irreversible in practical and economic terms. Desertification in its initial stage may merely involve a shift to a more desert-like and less productive ecosystem. This means that energy and nutritional balances will be less favourable to

plant growth than before. The preventive measures can be in the form of socio-economically appropriate land-use practices that improve the fertility of microclimates and soils and prevent desertification from making further encroachments.

In many cases, the users of dry land are guilty of having introduced inappropriate technologies like deep ploughing of croplands or excessive pulverization through mechanical tillage of top soils. Technical innovations are often brought in from more humid environments without due regard for the particular equilibrium of dryland ecosystems. For instance, introduction of deep wells has improved the availability of water but it has increased the herd size because more animals can now be watered at the well. Concomittantly, these animals do not venture very far from such wells, so herd mobility has decreased. This, in turn has led to local overgrazing and excessive trampling around the new watering points.

Traditional systems of land use have met these environmental challenges in various ways. For instance, pastoralists may herd several kinds of animals, each capable of profiting from different parts of the ecosystem, so that local over-burdening is avoided.

The concept of proper land use should not be confined to agricultural practices alone. It should be the guiding principle even when the land is being used for commercial purposes or for creating infrastructure. Today dry lands are being increasingly used for constructing cities, roads and highways, pipelines and canals. A lot of mining activities are being carried out in dry lands. Perhaps it is not possible to stop the use of dry lands. But due importance should be paid to the prevailing delicate natural balance. Traditional social values must be recognized, and the life styles and ancient knowledge

developed through long adaptation to the dryland environment must be respected.The approach should be an integrated one, in which proposals involving technological or environmental change are linked with social and economic measures undertaken to advance development.

The United Nations Convention to Combat Desertification intends to tackle the problem of desertification, by adopting a partnership approach between governments and local populations. The Convention aims to encourage local communities to regain a sense of respect for, and understanding of, their land and the climatic factors which affect it. Uncertainties concerning the underlying causes of desertification have already hampered previous international efforts to combat the problem. It is inevitable that negotiations regarding the desertification convention will be rendered more complicated because of these same uncertainties.

In the 20th century not much success was achieved in reversing desertification. But time may be running out for Planet Earth. It would be possible to succeed only if the peoples of the world are prepared to unite and fight against the encroaching deserts. And to fight effectively everyone must understand the underlying causes of desertification and remedies.

Interesting Facts

1. Deserts have existed throughout the history of the planet Earth.
2. Deserts are defined as regions that receive annual precipitation of less than 250 mm.
3. Deserts experience the most unpredictable rainfall patterns anywhere in the world.
4. Deserts cover vast areas of the Earth. After the oceans, deserts are one of the most extensive environment systems. About one-third of the Earth's surface is covered by deserts.
5. Most deserts lie near the Tropic of Cancer and the Tropic of Capricorn—the two lines of latitude lying about 30 degrees from the equator.
6. Deserts are not static. They expand and contract over time.
7. Only about 15-20 per cent of the total area of the world's deserts is pure sand.
8. Rub Al Khali in Arabia is the largest single sand sea. It covers an area of about 56,000 square kilometres.
9. Deserts experience a wide variation of temperature between day and night.

10. The Sahara Desert is the largest desert in the world.
11. The Sahara Desert is believed to be the world's largest source of dust—its annual turnover of dust lies somewhere between 60 to 200 million tonnes.
12. The Atacama Desert is the driest desert in the world.
13. Saguaro cacti are the largest plants found in deserts.
14. The Camel is called the "ship of the desert".
15. Deserts are home to a surprisingly wide range of animal species including mammals.
16. An annual grass (*Stipagrostis gonatostachys*) that grows in the Namib Desert survives even when precipitation is as low as 10 mm.
17. 13 per cent of the world's population live in deserts.
18. A dark, shiny stain, called desert or rock varnish, is often found on surfaces of desert rocks that have been exposed for a long period of time. Manganese, iron oxides, hydroxides, and clay minerals are the cause behind this "varnish".
19. Desert pavement forms when wind removes all of the fine-grained sand from a system, leaving only the coarse gravel behind.

Glossary

Aestivate: To spend the time between rainfalls in a dormant state. This is the summer version of hibernation.

Alluvium: Sand, clay, and gravel gradually deposited by moving water as along a riverbed or the shore of the lake. Alluvium is highly fertile and supports agriculture.

Aquifer: An underground layer of porous rock, sand etc., containing water into which well can be sunk. The term "aquifer" usually refers to water deposits that are used by humans.

Arid: Describing climate regions that lack enough water for things to grow. Such regions usually have an average rainfall of less than 200 mm.

Badlands: Barren plateau that are marked by dramatically eroded hills and containing many fossil deposits Badlands are the types of deserts where erosion is rapid and are devoid of vegetations.

Bedouin: An Arab of any nomadic desert tribes of Arabia, Syria or North Africa.

Biodiversity: The diverse in number or variety in the living things in a particular area of or region.

Biome: Any of several major life zones of interrelated plants and animals determined by the climate. Earth's surface

can be divided into several biomes. The biomes are discontinuous but animals and vegetation in one part of a biome generally resemble those in other parts. Boundaries between biomes are very rarely distinct. Often a biome merges gradually into its adjacent transition zones called ecotones. Major land biomes are tundra, taiga, temperate forest and rain forest, temperate grassland, chaparral, desert, tropical rain forest, tropical deciduous forest, tropical scrub forest, tropical savanna, mountains and ice cap.

Carrying capacity: The maximum number of grazing animals, that a given area of pastoral land sustain without degrading through overgrazing or other problem.

Climate: The prevailing or average weather condition of a place, as determined by the temperature and meteorological changes over a period of years.

Conservation: The act or practice of conserving or the protection from loss, waste etc. It usually refers to human care, protection or management of natural resources including plants and animals.

Continentality: It refers to condition and effects of a continental climate. The climate of a region located in central parts of a continent (vast landmass) is not attracted by maritime influences. Such a region lacks moisture and has pronounced differences in temperature between summer and winter.

Crescentic dune: Crescent-shaped mounds of sands. Certain types of crescentic dunes are known for their speed of movement. Crescent dunes are also known as barchans.

Deflation: Renewal of loose top soils by the wind driven processes.

Desertification: Desertification refers to the gradually degradation of productive arid or semi-arid land into biologically unproductive land.

Desert wind: A wind that blows off the desert. It is hot in summer, cold in winter, and very dry.

Desiccation: A long-term decrease in amount of surface water and/or groundwater in a region as a consequence of climatic change.

Drought: A prolonged period of dry weather, lack of water.

Ecosystem: A system made up of a community of animals, plants and bacteria and its interrelated physical and chemical environment.

Environment: Refers to set of physical and biological conditions or circumstances prevailing in a certain area that affect an organism or species.

Equator: An imaginary circle around the Earth, equally distant at all points from both the North and South poles. The equator divides the Earth's surface into the Northern and Southern Hemispheres.

Erosion: The process of wearing away of rock and the removal of land surface chiefly by the action of sands driven by wind or water.

Evaporite: A substance dissolved in a liquid that is left behind, when the liquid evaporates. Such substance is called an evaporite.

Flash flood: Brief violent stream of water usually caused by a sudden heavy rainfall. Flash flood are common in deserts.

Fossil water: Water lying underground for thousands of years. Fossil water is found in a region where the climate was wetter than it is at present.

Ground water: Water found underground in porous rock layer and soil.

Hadley cells: A direct, thermally driven and zonally circulation of air in which hot, moist air rises at the Equator, moves towards the poles to a latitudes of about 30 degree and then cools and stinks, flowing back towards the Equator. George Hadley first proposed the concept of Hadley cell as an explanation for the trade winds.

Harmattan wind: A dry, dusty wind that blows from the Sahara in North Africa toward the Atlantic Ocean

High pressure zone: Weather system with high atmospheric pressure in which air sinks, diverges outwards and disperses clouds.

Hyper-arid: Describing a climatic region with an average annual rainfall of less than 25 millimetres.

Ice age: Any part of geologic time when large parts of the earth were covered with glaciers. Ice age is also known as glacial epoch.

Inselberg: Isolated hills that stand out above the surrounding flat desert surface. They are the remains of long-eroded mountain ranges.

Lichens: Combinations of fungi with algae or sometimes with blue-green bacteria called cyanobacteria. These smaller plants have no root systems, but absorb water vapour from the atmosphere.

Linear Dunes: Long, sinuous dune that extends in fairly straight line. They may extend several kilometres. Linear dunes are the most common type of dunes that occur in deserts. A linear dune is also known as a seyf.

Locusts: Grasshoppers that undergo sporadic increases in population size to form huge swarms, which migrate long distances and devour all the crops and other vegetation on which they settle.

Mesa: A mesa is a steep-sided eroded remnant of a plateau.

Oasis: A fertile place in a desert, due to presence of water.

Playas: A desert basin that temporarily becomes a shallow lake after heavy rains.

Prairies: The extensive grasslands of the interior North America. Today there is very little of the original true prairie as they have been extensively ploughed for wheat production.

Precipitation: A depositing of rain, snow, sleet etc.

Rain forest: A thick evergreen typical forest found in areas of heavy rainfall and containing trees with broad leaves that form a continuous canopy.

Rain shadow: This refers to the phenomenon in which air masses move up, moisture develops into clouds and falls as rain but on the other side of the range, the subsiding air is extremely dry.

Runoff: Surface water that moves over the land after rainfall is called runnoff. This is excess of the amount that is absorbed by the ground.

Salinisation: Increased levels of salt caused by a variety of processes involving the evaporation of water.

Saltation: Jumping motions of sand particles that are being move by the wind.

Sand: Fragments of rock with particle size of between 0.2 and 2 millimetres. Particles smaller than this size are usually referred to as dust.

Sand storms: A wind storm in which large quantities of sand are blown about in the air in close proximity to the ground.

Savanna: A treeless plain or a grassland characterized by scattered trees especially in tropical or subtropical regions having seasonal rains.

Sleet: Precipitation consisting of drops of water frozen on their surface.

Slip Face: The sloping lee ward surface of a sand dune.

Semi-arid: Describing climatic regions with an average annual rainfall of less than 600 millimetres.

Soil: The surface layer of Earth, supporting plant life.

Steppe: Any of the great plains of South East Europe and Asia, having few trees.

Stratum: A single layer of sedimentary rock. Each stratum corresponds to a particular period of sedimentation.

Succulent: Any of a large group of flowering plants including the cacti with thick, fleshy stems and leaves. These plants are specially suited to thrive on arid region.

Torrid Zone: The area of the Earth's surface between the Tropic of Cancer and the Tropic of Capricorn and divided by the Equator.

Trade wind: A wind that blows steadily toward the equators from the northeast in the tropics north of the Equator and from southeast in the tropics south of the Equator.

Tropics: The two circles of the celestial sphere parallel to the celestial equator, one the Tropic of Cancer, c. 23^0 26′ north, and the other, the Tropic of Capricorn, c.23^0 26′ south. These are the limits of the apparent north-and-south journey of the Sun and are determined by the obliquity of the elliptic.

Tundra: Any of the vast, nearly level, treeless plains of the arctic regions.

Upwelling: Rising of cold water from the depths of the sea to the surface.

Wadi: River or stream that flows only during and following rainfall and is at all other times dry. Wadi is also known as arroyos.

Water table: The level below which the ground is saturated with water.

Weathering: A process by which exposed rocks are broken down on the spot by the action of rain, frost, wind, and other elements of the weather.

Yardangs: A large, irregular ridge with sharp crest sited between two round-bottomed troughs that have been curved in deserts by wind-driven processes.

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As part of International Year of Planet Earth-2008.

On UNO initiative, year 2008 has been proclaimed as International Year of Planet Earth. As part of Planet Earth – 2008, Vigyan Prasar has taken up an ambitious project to create awarenesses to what extent the Earth's system is part of our daily lives and, in term, which of our activities inter fare with those delicately balance systems and to create a sustainable future for the human and this planet.

Some titles of series International Year of Planet Earth 2008 of Vigyan Prasar include:-

1. *The Weather Riddle* by Biman Basu
2. *Planet Earth in a Nutshell* by Biman Basu
3. Earth's Changing Climate by Biman Basu
4. *The Violent Earth: Earthquake, Volcanos and Tsunami* by Subodh Mahanti
5. *Deserts: Driest Places on Earth* by Subodh Mahanti
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7. *Snakes* by Sukanya Datta
8. *Mangrove: The Tidal Forest* by R. Panneer Silivam
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